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Robert Hooke as an Astronomer

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The name of Robert Hooke, the English natural philosopher, is associated in the text-books of physics with the fundamental law of elasticity. To the student of the origins of modern science, however, it holds a richer content of associations. Hooke was one of the most vital and creative personalities of the age which first systematically combined purposive experiment with mathematical analysis in the pursuit of natural knowledge. As a chemist he formulated a rational hypothesis of the rôle of air in combustion and respiration. In physics he was the first to work out a wave theory of light and to attempt to explain the iridescence of thin films. With his improved microscope he revealed the cellular structure of organic tissue and the minute anatomy of insects. He made the barometer and the air pump serviceable, and he invented the principal meteorological instruments. More particularly in the realm of astronomy he contributed materially to such advances as the application of the telescope to measure celestial angles, the perfection of mechanical timekeepers, the search for annual stellar parallax, the generalization of the force of gravity into a cosmic agency, and the valid representation of the solar system as a self-acting mechanism. Hooke's share in these momentous developments of the "century of genius" fills a somewhat neglected page in the history of our science which may justly claim attention in the present series of studies.

Robert Hooke was born, the son of a clergyman, in 1635 on the Isle of Wight, off the south coast of England.[1] As a sickly child he amused himself with the construction of mechanical toys; later, in school days at Westminster, he excelled in mathematics and in classical and oriental languages. Going up to Oxford in 1653, he found himself among the brilliant set of experimental philosophers who there constituted a branch of what was to become the Royal Society. It was one of these men, Seth Ward, who interested Hooke in the study of the heavens. Ward held the professorship in astronomy established at Oxford in 1619 by Sir Henry Savile, of which the present holder is Professor H. H. Plaskett. Hooke's inventive and mechanical skill brought him to the notice of another member of the group, Robert Boyle the chemist, whose technical assistant he became, and whom he helped materially in the design and construction of an improved air pump and in the verification of the famous Law connecting the pressure and the volume of a gas. In 1662 Hooke was released by Boyle from his duties to become Curator of Experiments to the newly incorporated Royal Society in the

service of which (in various capacities) the remainder of his life was to be spent.

In 1665 Hooke was appointed a professor at Gresham College. Sir Thomas Gresham was a sixteenth century merchant prince who, when he died, left his spacious mansion in the heart of London to be turned into a college for the instruction of the citizens. Seven resident professors were to lecture in rotation on the various branches of learning, including astronomy; though actually it was the Chair of Geometry which was now assigned to Hooke. Gresham College had been a favorite *rendezvous* for the London set who formed the embryonic Royal Society; after they had received their charter in 1662 it became their official meeting-place, and already by 1664 Hooke had taken up his lifelong abode there. Owing to the civil disorders of the seventeenth century and the frailties of the professors, Gresham's intentions had been but imperfectly fulfilled; and Hooke's lectures at the College were mostly delivered upon the foundation which Sir John Cutler had established for him in 1664. A glance at the second (in order of publication) of these Cutler Lectures will serve to introduce us to some of the technical problems which preoccupied Hooke and the other observing astronomers of his day.[2]

About 1665 Hooke had been drawn into a controversy with the distinguished astronomer Johannes Hevelius of Danzig concerning the relative merits of the so-called "plain" and "telescopic" sights. Tycho Brahe, the great Danish observer of the sixteenth century, had established a standard type of instrument for measuring angular distances upon the celestial sphere. It consisted essentially of a quadrant, or some such sector of a circle, strongly made of wood or metal, having its circumference graduated in angular measure, and traversed by a radial pointer which turned about the geometrical centre of the sector. The plane of the instrument was first made to coincide with that determined by the observer's eye and any two stars, say, whose angular separation was required. The pointer was then directed to each star in turn; each setting was read on the graduated limb of the sector, and the difference of the two readings gave the angle sought. The pointer was directed by means of two sights, one consisting essentially of a narrow slit and the other of a straight edge. The visual ray, grazing the one and passing through the other, accurately defined the direction of the distant star. Prior to the introduction of the pendulum clock, the whole of precise astronomy depended upon observations of this type. Hevelius, carrying on the tradition of Tycho Brahe through the seventeenth century, prided himself upon the size of his instruments and upon the refinement of their graduations, which enabled him to take readings to a few seconds of angular measure.

Hooke, however, pointed out that, since the human eye is incapable of distinguishing between angles which differ by less than one or two minutes or arc, all measurements made with the costly instruments of

Hevelius must necessarily be subject to an uncertainty of that order. He urged the Danzig astronomer to adopt the "telescopic" sight which was coming into use about this period, particularly among the astronomers of the Paris Academy of Sciences. This innovation involved the use of a telescope as the centrally pivoted radial index in place of the sight-carryng pointer of the older instruments. The telescope was equipped with a pair of hairs, or silk threads, intersecting at right angles in the focal plane of the object glass, the point of intersection of the hairs forming, with the optical centre of the glass, a line of collimation which served to define a precise direction in space, just as the pair of open sights had formerly done. The use of the telescopic sight reduced the proportional uncertainty in the estimates of celestial angles; it further made for accuracy by forming the image of the remote star in the plane occupied by the hairs, so that both star-image and hairs were simultaneously in focus with the same adjustment of the eye-piece, and of the eye. It was in vain, however, that Hooke pressed these considerations upon Hevelius. The Danzig astronomer made brilliant use of the telescope as an aid to purely descriptive work, such as mapping the Moon; but for precise celestial measurements (*e.g.*, in the preparation of his star catalogue) he refused to equip his instruments with lenses as he feared that these might produce unsuspected deviations of the rays refracted through them, or might be jolted out of adjustment during use.

The publication by Hevelius, in 1673, of a beautifully illustrated account of his observatory and its instruments[3] drew forth from Hooke a critical review which forms the early part of his Cutler Lecture of 1674. Hevelius considered that it cast doubt upon the honesty of his claims to have attained extraordinary accuracy of observation, and he appealed to the Royal Society to send a deputation to put him to the test. That was how it came about that, in 1679, the youthful Edmond Halley, newly returned from cataloguing the southern stars at St. Helena, repaired to Danzig with a telescopic quadrant to observe in friendly rivalry with the veteran astronomer. He bore witness to the good faith of Hevelius; otherwise his sympathies were with Hooke, and he concealed his real opinion of his host's technique only to avoid the risk of hastening the departure of "an old peevish gentleman."[4] The controversy smouldered on inconclusively until the death of Hevelius in 1687.

From his criticisms of Hevelius, Hooke passes on in his lecture to describe an astronomical instrument of his own contrivance embodying several inventions which have proved fruitful. These included the use of a slow-motion screw with a graduated head enabling the setting of the telescopic sight to be read to a second of arc; also the provision of a water-level in preference to a plumb-line to determine the horizontal, and the mounting of the whole instrument equatorially upon a polar axis slowly turned by an adjustable clockwork device so as to keep pace

with the diurnal motion of the celestial sphere. This primitive "driving clock" embodied what is still known as "Hooke's universal joint" for transmitting rotation from one shaft to another making an angle with the first. Hooke claims to have had his quadrant actually constructed by Thomas Tompion, the noted London clockmaker of the period. He was anxious that instruments of this type should be employed to detect the "proper motion" of stars (a phenomenon which he anticipated nearly fifty years before Halley actually established it) ; other uses to which it was to be put included investigating the laws of atmospheric refraction, estimating the angular distances of planets from stars as a means of obtaining standard time and so determining longitude, and finding the length of a degree of latitude by measuring the zenith distances of stars in transit from stations at each end of a known meridian arc.

Hooke was also interested in the development of another now indispensable astronomical instrument, the micrometer for measuring the small angles between objects simultaneously visible in the field of a telescope, or the angular diameters of planets. The earliest micrometer seems to have been constructed by a young English astronomer, William Gas-coigne, about 1640. He died fighting in the royalist ranks in the Civil War, but his micrometers came into the hands of Richard Towneley, a wealthy amateur, who put one of them into working order and used it to observe Jupiter's satellites. Hooke published an illustrated account of Towneley's micrometer in 1667.[5] The instrument presented, in the centre of the field of the telescope, two parallel hairs or straight edges of metal; by turning a screw these could be separated by amounts measurable with great exactness on the graduated head of the screw, the factor for converting the arbitrary units into angular measure being determined from observations as now. Meanwhile the familiar bifilar micrometer was being introduced by the astronomers of the Paris Academy. One of Towneley's micrometers was presented to John Flamsteed when, as a young provincial amateur, he paid his first visit to London in 1670. On this occasion Hooke helped Flamsteed to obtain telescope lenses at half price for the little observatory which the latter was establishing at his home in the north of England. Hooke served on the Commission appointed in 1675 to consider St. Pierre's proposed method of determining longitude. The adverse verdict of the Commissioners drew attention to the faulty state of the existing lunar tables and star catalogues and thus hastened the establishment of Greenwich Observatory.

Flamsteed's relations with Hooke became less cordial with the passage of time. Flamsteed was dissatisfied with the 10-foot mural arc which Hooke had constructed for the Royal Observatory, and he resented Hooke's somewhat hasty withdrawal of the loan of one of his quadrants which the Observatory could ill afford to lose.[6] To mention one more link between Hooke and Greenwich, when Halley, succeeding Flamsteed as Astronomer Royal in 1720, set about re-equipping the Royal Ob-

servatory (denuded of instruments by the executors of his predecessor), he is reported to have used for his new transit instrument (the first ever seen there) a telescope of Hooke's construction.[7]

In another of his Cutler Lectures, published in 1676, Hooke explained his design for constructing a helioscope.[8] This was to be a telescope through which the Sun could be safely observed, the intensity of his rays being conveniently diminished by repeated reflections from dark glasses in the interior of the instrument. Hooke recommended the use of such reflections as a means of shortening the tubes of telescopes of great focal length and making them easier to handle, somewhat as in the modern binocular. He also realized that if the rays entering a helioscope were allowed to fall first upon a *concave* reflecting surface, they would thereby be brought to a focus and there would be no need to furnish the instrument with an object glass. Hooke kept experimenting with various mechanical contrivances for grinding lenses and specula; and already in 1674 he had produced for the Society a reflecting telescope constructed upon the principle devised by James Gregory, which he asserted to be the first "Gregorian" ever actually made. Newton's reflector, working on a somewhat different plan, was already well known by that time. In his Lecture of 1676 Hooke hints at something in the nature of the modern coelostat, to be constituted by fixing horizontally a telescope of otherwise unmanageable length and employing a rotating mirror to direct into the object glass a beam from the celestial body under observation.

In 1673 Huygens had brought out his great book on the pendulum clock. Hooke was disappointed that the Dutch physicist should have made no acknowledgement of his own prior invention of the so-called circular (or conical) pendulum. He also contended with the followers of Huygens (with justice, it would appear) for the priority in the invention, about 1658, of the balance spring for regulating the beat of a watch, "the most important single improvement ever applied to portable timekeepers";[9] and he was among those who experimented unsuccessfully with marine clocks designed to show standard time at sea for the purpose of determining longitude. Among Hooke's papers there was found his invention of an instrument for measuring the altitude of a celestial object above the sea horizon; it never came into use, and, in any case, it would have been superseded like others of its kind upon the introduction, in the eighteenth century, of the nautical sextant.

The records of the Royal Society show that Hooke was a keen observer of celestial phenomena, employing the long-focus telescopes of his day to follow eclipses, occultations and the motions of Jupiter's satellites, to locate new and variable stars, and to scrutinize comets and the surfaces of the planets. In 1664 he noticed the progressive displacement of a spot across the bright disc of Jupiter, and he was thus led to infer that the planet rotates axially.[10] Two years later he made a similar discovery concerning Mars;[11] his drawings of the surface mark-

ings at a stated time were subsequently utilized by R. A. Proctor in determining the planet's period of axial rotation.

In December, 1674, the Gresham Committee allowed Hooke £40 to cover the cost of constructing a turret over his rooms in the College to serve as an observatory. He was already in the habit of observing through an opening in the roof, as appears from the account which he gives, in the first of his Cutler Lectures to be published, of one of the most significant of all his astronomical enterprises—his pioneer attempt to detect annual parallax in a star by telescopic observation, and thereby to prove that the Earth revolves about the Sun.[12]

By the middle of the seventeenth century, the heliocentric theory was widely accepted, especially in Protestant England; but the failure to establish stellar parallax continued to place the followers of Copernicus in a grave difficulty from which they could escape only by consigning the stars to what was felt in those days to be an incredibly remote region of space. Hooke inclined towards the heliocentric theory; and he adopted a procedure designed to exclude the sources of error which he believe to have foiled the efforts of his predecessors to observe the elusive phenomenon of parallax. Among these disturbing factors he instanced particularly the tendency of the old instruments to suffer deformation under their own weight or through changes of temperature, the deficiencies of the graduated scales, the effects of atmospheric refraction in increasing the apparent altitudes of the stars by uncertain and incessantly varying amounts, and, especially, the limited resolving power of the human eye.

Hooke's own apparatus was equivalent to a telescope fixed with its axis pointing vertically upward to the zenith (where refraction is zero), but without the customary tube connecting the lenses. The object-glass, 36 feet in focal length, was mounted in a sort of wooden box projecting through the roof of Hooke's lodging. The eye-piece was supported on a sliding frame in the next story below, a hole being cut in the intervening floor so as to afford a clear view to the observer, who lay on his back on a couch under the eye-piece and looked straight upward. In the common focal plane of the object-glass and the eye-piece two hairs were fixed whose point of intersection was adjusted, with the aid of a plumb-line, so as to lie perpendicularly under the centre of the object-glass. Thus the image of a star in the zenith would coincide with the intersection of the hairs. There was also a micrometer by means of which the observer could estimate, in seconds of arc, the angular distance from the zenith at which any star passing through the field of the telescope crossed the meridian. Hooke's plan was to determine the meridian altitude of a star at different times of the year by means of this micrometer, and to note whether this altitude showed seasonal fluctuations attributable to parallax. He selected the star γ *Draconis*, which passes close to the zenith in the latitude of London and which is also near to the pole of the ecliptic where parallactic displacements are most appre-

ciable. Beginning in July, 1669, he observed the star at intervals until the following October, when he was obliged to break off owing to illness and unfavourable weather. The measurements he obtained seemed to show a progressive increase in the angular distance of the star from the north pole which led him to believe that he had indeed obtained "a confirmation of the Copernican System," and that the range of the annual fluctuations in meridian altitude of γ *Draconis* would amount to about 30 seconds of arc. In this estimate Hooke must, of course, have been misled by some progressive change in the disposition of his apparatus, since Bradley's subsequent investigations on the same star (which led him to the discovery of aberration) showed that its parallax certainly could not exceed 2 seconds.

The star was visible through the apparatus in broad daylight; and Hooke believed himself to be the first to make such an observation. He also noticed that the star, when thus viewed, appeared, not as a disc, but as a mere point of light. It was still generally believed in the seventeenth century that the brighter stars subtended appreciable angular diameters at the observer's eye; and this was used to disprove the Copernican theory. For it was argued that if the stars appeared as discs although sufficiently remote to show no sensible parallaxes, they must be of preposterous size in themselves—perhaps larger than our whole planetary system. By establishing that the disc was an optical illusion, Hooke claimed to have demolished this argument. He explained the twinkling of the stars by reference to the inequalities in optical density, and the constant disturbances, of the atmosphere; this is a matter still capable of producing a lively discussion.[13]

In the concluding lines of his lecture on parallax, Hooke touches upon a problem of growing concern to him and to his contemporaries at this period—that of explaining the motions of the planets upon mechanical principles. His earliest recorded speculations upon gravitation would appear to be those embodied in his tract *Cometa*.[14] This was a lecture called forth by the great comet of 1677 and was published in 1678; but its theories are based upon the notes of Gresham College lectures on the comets of 1664 and 1665, which he delivered early in the latter year. The tract therefore reflects his views on gravitation at a period antedating all Newton's recorded speculations on the subject. The investigation of the physical constitution of comets was still scarcely regarded as falling within the purview of astronomical science. Hooke distinguished between the star-like "nucleus" of a comet, the luminous "coma" surrounding the nucleus, and the extended "blaze," or tail. He surmised that the dense nucleus might be pulled along by the "gravitating principle" of a more powerful body, leaving behind it those portions of itself which had been dissolved in the surrounding aether to form the tail. "For," he writes, "I suppose the gravitating power of the Sun in the center of this part of the Heaven in which we are, hath an attractive power upon all the bodies of the Planets and of the Earth that

move about it, and that each of those again . . . may be said to attract the Sun in the same manner as the Load-stone hath to Iron, and the Iron hath to the Load-stone. I conceive also that this attractive virtue may act likewise upon several other bodies that come within the center of its sphere of activitity," namely comets.[15] Or perhaps, while the nucleus is attracted by the Sun's gravitation out of its naturally straight course, the material escaping from it into the aether is repelled to form the tail, just as some bodies are attracted and some repelled by the same magnetic pole. The conception of a comet's tail as formed by a repulsion from the Sun, whether of an electrostatic nature or due to radiation pressure, was to become familiar during the nineteenth century. In any case, Hooke regarded the tail as maintained at the expense of the slowly wasting nucleus. He recommended determining the distance of a comet by measuring its diurnal parallax and thereby finally deciding the dispute as to whether it was an atmospheric or a celestial phenomenon. He sought to fit approximate orbits to the comets he observed; the results, although strictly inconclusive, encouraged him to believe that those bodies sometimes moved in circles or ellipses, and that the same one might become visible at regular intervals.

The conception which Hooke formed of gravity as an agency comparable to magnetism links up his speculations with those of Gilbert and Kepler half a century earlier. It naturally led him to expect a falling-off in the force of gravity with increase of distance from the Earth, a phenomenon which he sought to establish experimentally in several different ways, beginning as early as 1662.[16] Taking a pair of scales (a balance) to some lofty elevation, he placed in one pan a mass of iron and a length of wire, and in the other pan sufficient weights to balance these exactly. He then hung the iron from its pan by means of the wire so that it descended nearly to the ground; as it was now nearer to the Earth it should have weighed heavier and required more weights to counterpoise it. Alternatively he utilized his newly invented spring balance, consisting of a light scale-pan suspended by a helical spring. It was based on the law of elasticity which he had discovered about 1660, the absolute weight of a body placed in the pan being measured by the proportionate extension produced in the spring. He employed the instrument to test whether the pull of gravity upon a body decreased in rising from ground level to the top of a lofty building. Two historic London piles, Westminster Abbey and old St. Paul's (the latter soon to be destroyed in the great Fire of 1666) served him for both these experiments. He also had trials made down deep wells and mine-shafts. Much later, in 1681, Hooke proposed to demonstate the variation of gravity by showing that a pendulum clock would go slower at the top than at the foot of the Monument (a tall column erected in the City to commemorate the said great Fire). In none of these trials, however, were his methods sufficiently sensitive to give positive results.

In the concluding "Observation" of his *Micrographia* of 1665, Hooke

expressed the opinion that the Moon was composed of materials similar to those of the Earth, and that it probably possessed an attractive principle of its own comparable to terrestrial gravity.[17] He based this view upon the Moon's globular form, and upon the appearance of its craters; these, viewed through the telescope, seemed to correspond exactly to terrestrial volcanoes formed (as he supposed) by the eruption of heated subterranean vapours through overlying rocks and soil which thereafter fell back under gravity into characteristic contours. Hooke had at first tried to reproduce the peculiar forms of the lunar craters by dropping a bullet into a mixture of pipe-clay and water. However, he found it impossible to conceive how any projectile could strike the Moon; hence he preferred to compare its surface structure with that of "a pot of boyling Alabaster" set aside to cool, the bubble-scars exactly resembling the craters.[18] On the other hand, he conceived the Sun's surface to be composed of mutually combustible substances, such as sulphur and nitre, the sunspots being clouds floating in an atmosphere.[19] In Hooke's day the favourite explanation of gravity was that of the French philosopher Descartes. He attributed the fall of heavy bodies to the mechanical action of a vortex of aether circulating round the Earth in association with the diurnal rotation of the latter. That the Moon, though (supposedly) not rotating upon an axis, yet possessed a principle of gravitation, seemed to Hooke to dispose of the Cartesian theory of gravity. On an earlier page of his *Micrographia,* Hooke refers to the "decrease of the power of gravity" with increase of distance from the Earth, although without explicitly formulating the law of its variation.[20] The book was printed in the autumn of 1664 and published in January, 1665. It enjoyed a wide circulation, and it could have been known to Newton at the time of his Woolsthorpe speculations of 1665-66, when he, too, wondered how far the influence of gravity extended into space, and arrived at a tentative law of its variation with distance.

Again, in 1666, Hooke explained to the Royal Society his views on what made the planets revolve in closed orbits round the Sun.[21] The idea of the solar system as a mechanism working under universal physical laws had only recently begun to establish itself among the bolder thinkers. The medieval philosophers had regarded the motion of a planet as just one of those spontaneous processes by which substances strove towards a more perfect fulfilment of their rôles in nature. Kepler had made the Sun the seat of a magnetic power driving the planets forward in their orbits. Descartes had grasped the Principle of Inertia, later embodied in Newton's first Law of Motion. Hooke, starting out from the point reached by Descartes, saw that a force was needed, not to push a planet along from behind, but to pull it in towards a fixed centre so as to make it describe a closed curve instead of traveling off along a tangent into outer space. He conceived this force as an attraction exerted by the Sun upon all material bodies in its neighbourhood; and he sought to reproduce the behaviour of a planet (after a fashion) by

means of a conical pendulum in which a weight suspended from a fixed point of support revolved in a circle under a force supplied by the tension in the cord and acting inwards. In the brief reference to the problem which occurs (as we have already noted) at the conclusion of his lecture on stellar parallax (delivered in 1670 and published in 1674), Hooke makes the supposition that all the heavenly bodies attract to their respective centres not only their own parts but also one another.

From 1679 onwards, Hooke's views on the cosmic rôle of gravitation developed under the stimulus of correspondence and controversy with Isaac Newton, who, more than ten years before, had investigated the possibility of the Moon's being kept in its orbit by the force of terrestrial gravity. The two men had become somewhat estranged following Hooke's lively criticisms of Newton's theory of colours; but, in response to Hooke's approach to him on the fresh topic of planetary theory, Newton threw out the suggestion that a diurnal rotation of the Earth should have the effect of causing a freely falling body to show an *eastward* deviation from the vertical.[22] Hooke lost no time in putting this prediction to the test of experiment, both in the open air and in the hall of his favourite coffee-house. By dropping a bullet into moist pipeclay, he claimed to have established an appreciable *south-eastward* deflection of the falling body—somewhat over-optimistically, perhaps, to judge from the excessively minute deviations registered by later experimenters releasing bodies from much greater heights with elaborate precautions against error. Yet it is a fact that the eastward deviation is complicated by a southward component for which it is hard to furnish a convincing theoretical reason. There ensued a correspondence between Hooke and Newton as to the path which would be followed by a heavy particle if it could fall towards the Earth's centre without obstruction. In the course of this discussion Hooke came out with the hypothesis that, above ground level, the force of gravity varies inversely as the square of the distance from the Earth's centre, but that, below ground, the attraction must fall off as the centre is approached with more and more of the Earth's substance lying above the particle and pulling it upward. He pressed Newton to establish mathematically what curve should be described by a body under a central force subject to the inverse square law. It did not take Newton long to prove that the required curve is an ellipse (more generally, a conic) with the centre of attraction in one focus; but he kept his discovery to himself, and it was not until nearly five years had elapsed that, at the instigation of Edmond Halley, Newton embarked upon the spell of intensive research which resulted in the publication of his *Principia* in 1687.

Meanwhile Hooke's views on gravitation had undergone further development, as is evident from his discourse on the comets of 1680 and 1682, read in the latter year.[23] In the first place he had come to conceive the physical cause of gravitation as consisting in vibrations emanating from the attracting body, and analogous to those constituting

light. Thus he regarded the Earth as pulsating, each particle oscillating radially inwards and outwards. These oscillations, being communicated to the all-pervading aether, were propagated into space, and they caused neighbouring bodies to approach the Earth, just as blows applied to one end of the handle of an axe cause the axehead to travel up the handle in the opposite direction to that in which the blows act. To determine whether gravity always acts towards the centre of an exactly spherical Earth, Hooke recommended measuring the lengths of arc, each corresponding to one degree of the meridian, in widely differing latitudes, and seeing whether they were all equal. He argued that a diurnal rotation of the Earth should make any body upon its surface tend to recede "centrifugally" from the polar axis. This effect would be proportional to the radius of the daily circle described by the body, and would thus increase from zero at the poles to a maximum on the equator. It would partly counteract the weight of the body (for which there was some evidence in the shortening of the seconds pendulum in low latitudes), and it would act obliquely to normal gravity and so deflect the plumb-line from passing through the Earth's centre. In consequence the ocean surface should assume somewhat the form of an oblate spheroid, its shortest axis coinciding with the Earth's axis of rotation.[24] Hooke cited the oblate forms of certain planets, supposed to be in rapid rotation, in confirmation of his hypothesis. Already in 1683 he was drawing conclusions as to the figure of the Earth from the supposed equilibrium of two ideal columns or cones of liquid lying respectively along the polar axis and in the equatorial plane and communicating at the Earth's centre.[25] This treatment of the problem anticipated Newton's calculation, in the *Principia*, of the ellipticity of a meridian section of the Earth from a consideration of just such communicating "canals" in a rotating mass of mutually gravitating fluids. Lecturing in the winter of 1686-87, Hooke suggested that, in the course of ages, the polar axis might change its position in relation to the body of the Earth;[26] this would involve a corresponding displacement of the equatorial ocean protuberance, and also changes in the local direction of gravity at many places, leading to earthquakes. From both causes there must have arisen the past redistributions of sea and dry land suggested by the presence of marine shells on the tops of mountains.

Early in 1684 Hooke asserted, in the presence of his friends Halley and Wren, that he had demonstrated "all the laws of the celestiall motions."[27] His subsequent claims to have contributed materially to the establishment of the law of universal gravitation very nearly led Newton to suppress the third Book of the *Principia*. It is indeed difficult to estimate fairly the respective contributions of Hooke and Newton to the gravitational theory of the solar system. Some of Hooke's manuscripts which might have thrown light upon the matter were admittedly lost before they reached the hands of those who edited his works posthumously. Hence there has been a natural tendency to rely chiefly upon the

letters and memoirs of Newton and of his friends in building up an historical tradition which may well do less than justice to Hooke.[28] On the other hand, Newton would never admit that he had received any vital new information from Hooke, who, lacking the technique of the calculus, was hardly in a position to produce a rigorous demonstration of the elliptic orbit of a planet from first principles.

However that may be, Robert Hooke's researches and expositions unquestionably advanced astronomy in his day both by contributing to the technical progress of the science and by helping to prepare the minds of his contemporaries for a dynamical theory of the solar system and, indeed, for the whole conception of a cosmic régime of natural law. If he was apt to see in the achievements of others the fruition of his own inventions and to become involved in rancorous priority disputes, it was because the fertility of his restless imagination far exceeded his opportunities for patiently working out and formally publishing the ideas which came to him. Throughout his career Hooke was dogged by ill-health and overdriven by his duties, public and private. With the publication of Newton's *Principia* he saw himself robbed for all time of the prize for which he had striven and which he felt was within his grasp. Thereafter his disabilities and eccentricities grew upon him with the years until in 1703 he was released by death at the age of 67. "His Corpse," writes Waller, "was decently and handsomely interred in the Church of St. Helen in London, all the Members of the Royal Society then in Town attending his Body to the Grave, paying the Respect due to his extraordinary Merit."

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[15] *Cometa*, 12.

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[19] *Posthumous Works*, 94.
[20] *Micrographia*, 227.
[21] Gunther, *op. cit.*, vi, 265 ff.
[22] W. W. Rouse Ball, *An Essay on Newton's Principia* (London, 1893), 142 f.
[23] *Posthumous Works*, 149 ff.
[24] *ibid.*, 346 ff.
[25] *ibid.*, 456.
[26] *ibid.*, 346.
[27] Ball, *op. cit.*, 162.
[28] For a scholarly attempt to correct the balance of judgment, see Louise D. Patterson: "Hooke's Gravitation Theory and its Influence on Newton." *Isis*, 1949, xl, 327; 1950, xli, 32. The present writer has found these articles helpful in preparing the latter part of this paper.

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The Law of Planet and Satellite Distance

By ARTHUR BEISER

Abstract

When the mean orbital radius of the satellite nearest its parent body is subtracted from the mean orbital radii of the other satellites, the resulting distances are found to be in a geometric progression. This relationship is found to be true for the system of the Sun and the planets and for the satellite systems of Jupiter, Saturn, and Uranus when certain assumptions are made (*viz.*, the groups of the asteroids, Neptune and Pluto, the three outer satellites of Jupiter, the three satellites next to those, and the satellites Titan and Hyperion of Saturn are considered as single bodies revolving at the mean of their separate orbital radii). The formula

$$R_n = a\epsilon^{n-1} + R_0$$

is shown to represent the distances of the satellites and planets from their parent bodies with good accuracy. A number of orbits predicted by the above formula do not correspond to any known satellite and either contain bodies which have not been discovered or are unoccupied. The Bode-Titius "law" for planet distances is shown to be an approximation of the above formula.

Introduction

The validity of a theory of cosmogony depends primarily upon the degree to which it explains known phenomena of the solar system. Existing criteria for determining whether or not a particular theory is tenable are many (*e.g.*, the dynamical properties of the system), but an extremely significant one has been until the present time in a very unsatisfactory state. The spatial arrangement of the planets with respect to the sun has heretofore been represented mathematically only by the very approximate Bode-Titius relation (see below), and that of the various satellites with respect to their mother planets, not at all. However, by making a suitable deviation from the geometric procession used

by Bode and to be found in similar later formulae, not only the distances of the planets from the sun but also those of the satellites from their primaries may be expressed in a single formula.

1. Table 1 contains the mean orbital radii of the planets and these radii minus that of Mercury. Assuming a planet where the asteroids are and using the mean of the orbital radii of Neptune and Pluto the ratios between successive radii after the subtraction has been performed are approximately equal. This indicates the existence of a geometric progression among the latter distances, and hence that the expression for the nth term of such a progression

$$1 = ar^{n-1} \tag{1}$$

is applicable. In equation (1) a is the first term of the progression and r the common ratio. When applied to the solar system, equation (1) becomes

$$R_n = a\epsilon^{n-1} + R_0 \tag{2}$$

where R_n is the mean orbital radius of any planet, with the above conditions regarding the asteroids and Neptune and Pluto, a is the difference between the orbital radii of Mercury and Venus $(R_1 - R_0)$, ϵ is the ratio between any two successive terms

$$(R_n - R_0)/(R_{n-1} - R_0),$$

n is the number of the planet (starting with 0 for the innermost and then numbering consecutively outward) and R_0 is the mean orbital radius of Mercury.

2. When the process of subtracting the orbital radius of the innermost body in a satellite system from the other radii is applied to the multiple satellite systems of Jupiter, Saturn, and Uranus, geometric progressions among the remaining distances are again found (Table 2). Equation (2) holds for these systems, with the constants, of course, having different values. The three outermost satellites of Jupiter and the three next to those are considered as single bodies revolving with a radius the mean of their separate ones, as are the satellites Titan and Hyperion of Saturn. The above assumptions are analogous to those made in the cases of the asteroids and Neptune and Pluto. The gaps in the table represent satellite orbits which should exist according to equation (2) but which either contain bodies that have not been discovered or are unoccupied.

3. Table 3 contains the numerical values of the constants a, ϵ, and R_0 found in equation (2) for the different systems. Weighted averages were used for ϵ so as to provide best possible agreement with the measured values for R_n when substituted in equation (2). For the same reason the values for a in the cases of Saturn and Uranus differ slightly from those given by $(R_1 - R_0)$. Table 4 contains the measured values for the mean orbital radii of the planets and satellites and the values computed for them from equation (2). A number of orbits predicted from equation (2) are unoccupied, corresponding to the gaps in Table 2.

4. Bode's "law" (actually discovered by Titius) for planet distances may be shown to be an approximation of equation (2). Substituting numerical values in astronomical units for the constants, we have

$$R_n = (0.336)\ (1.95)^{n-1} + 0.387. \tag{3}$$

If the numerical values in equation (3) are rounded off to the nearest integer we have

$$R_n = 0.3\ (2)^{n-1} + 0.4, \tag{4}$$

which is the statement of Bode's law. Equation (4) may be put in the familiar tabular form by performing the indicated operations. The inaccuracy of Bode's law is due to the deviation of the constants used in it from their actual values as given in equation (3).

TABLE 1

Planet	Mean Orbital Radius (R_n)	Mean Orbital Radius Minus Mean Orbital Radius of Mercury ($R_n - R_0$)	Ratio Between Successive Terms (ϵ)
Mercury	57.87×10^6 km	0.0	....
Venus	108.14	50.27×10^6 km	....
Earth	149.50	91.63	1.83
Mars	227.76	169.89	1.85
Asteroids	.....	.....	....
Jupiter	777.82	719.95	....
Saturn	1426.1	1368.2	1.90
Uranus	2869.1	2811.2	2.03
Mean of Neptune & Pluto	5197.2	5139.3	1.83

TABLE 2

Satellite	Mean Orbital Radius (R_n)	Mean Orbital Radius Minus Mean Orbital Radius of Inner Satellite ($R_n - R_0$)	Ratio Between Successive Terms (ϵ)
(Jupiter)			
Nameless	181,500 km	.....	....
Io	422,000	240,500	....
Europa	671,400	489,900	2.04
Ganymede	1,071,000	890,300	1.82
Callisto	1,884,000	1,703,000	1.91
Undiscovered	.....	.....	....
Undiscovered	.....	.....	....
Nameless	11,500,000		
Nameless	11,730,000	11,490,000	....
Nameless	11,750,000		
Nameless	22,500,000		
Nameless	23,500,000	23,050,000	2.01
Nameless	23,700,000		
(Saturn)			
Mimas	185,700	.....	....
Enceladus	238,200	52,500	....
Tethys	294,800	109,100	2.08
Dione	377,700	192,000	1.76
Rhea	527,500	341,800	1.78
Undiscovered	.....	.....	....
Titan	1,223,800		

Satellite	Mean Orbital Radius (R_n)	Mean Orbital Radius Minus Mean Orbital Radius of Inner Satellite ($R_n - R_0$)	Ratio Between Successive Terms (ϵ)
	(Table 2, Continued)		
Hyperion	1,484,000	1,168,000	....
Undiscovered	.....	.....	....
Iapetus	3,563,000	3,397,000	....
Undiscovered	.....	.....	....
Phoebe	12,950,000	12,764,380	....
(Uranus)			
Ariel	191,800	.....	....
Umbriel	267,300	75,500	....
Undiscovered	.....	.....	....
Undiscovered	.....	.....	....
Titania	438,700	246,900	....
Oberon	586,600	394,800	1.60

TABLE 3

Central Body	a	ϵ	R_0
Sun	50.27×10^6 km	1.95	57.87×10^6 km
Jupiter	240,500	1.92	181,500
Saturn	60,000	1.78	185,700
Uranus	60,500	1.6	191,800

TABLE 4

Satellite	n	Measured Value of (R_n)	Calculated Value of (R_n)	Difference
(Sun)				
Mercury	0	57.87×10^6 km	.....	...
Venus	1	108.14	108.14×10^6 km	0.0%
Earth	2	149.50	155.90	4.3%
Mars	3	227.76	249.12	9.3%
Asteroids	4	.....	430.62	...
Jupiter	5	777.82	784.70	0.9%
Saturn	6	1426.1	1475.2	3.4%
Uranus	7	2869.1	2822.6	1.6%
Mean of Neptune & Pluto	8	5197.2	5447.0	4.8%
(Jupiter)				
Nameless	0	181,500	.....	...
Io	1	422,000	422,000	0.0%
Europa	2	671,400	643,300	4.2%
Ganymede	3	1,071,000	1,068,000	0.3%
Callisto	4	1,884,000	1,884,000	0.0%
Undiscovered	5	.....	3,450,000	...
Undiscovered	6	.....	6,457,000	...
Nameless	7_1			
Nameless	7_2	11,670,000	12,230,000	4.6%
Nameless	7_3			
Nameless	8_1			
Nameless	8_2	23,230,000	23,310,000	0.3%
Nameless	8_3			
(Saturn)				
Mimas	0	185,700	.....	...
Enceladus	1	238,200	245,700	3.1%
Tethys	2	294,800	292,500	0.8%
Dione	3	377,700	375,800	0.5%
Rhea	4	527,500	524,100	0.6%
Undiscovered	5	.....	788,000	...

Satellite	n	Measured Value of (R_n)	Calculated Value of (R_n)	Difference
Titan	6,	1,371,000	1,258,000	8.2%
Hyperion	6₂			
Undiscovered	7	.....	2,094,000	...
Iapetus	8	3,563,000	3,583,000	0.6%
Undiscovered	9	.....	6,232,000	...
Phoebe	10	12,950,000	10,949,000	15.4%
(Uranus)				
Ariel	0	191,800	.....	...
Umbriel	1	267,300	252,300	5.6%
Undiscovered	2	.....	288,600	...
Undiscovered	3	.....	346,700	...
Titania	4	438,700	439,600	0.2%
Oberon	5	586,600	588,300	0.03%

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Surveying for an Eclipse Expedition

By JAMES HARGREAVES

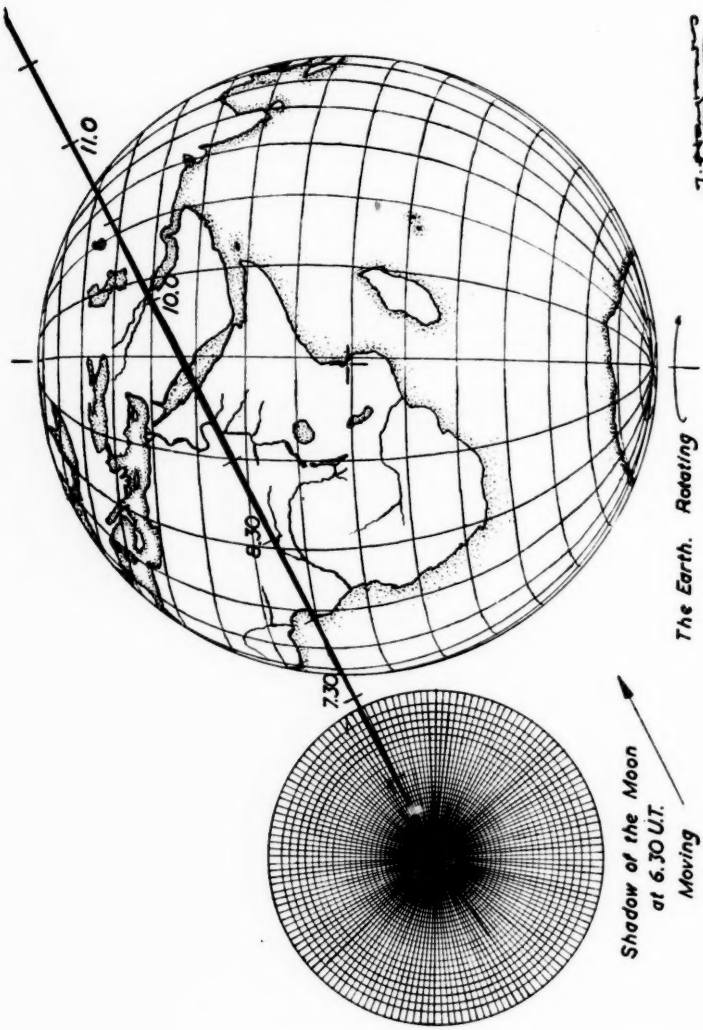
A study has been underway during the past year or more with the object of locating an expedition from the University of Ottawa to observe the total solar eclipse of 1952 February 25. The procedure followed is discussed in the hope that it may be of some general usefulness.

The requirements for a good eclipse camp are complex, but fall broadly into two classes, the human and the physical. The first class may be subdivided by political and economic causes, such as the attitude of national and regional governments, transportation services, housing and supply facilities, and costs. The physical requirements subdivide naturally as meteorological and astronomical. Each subdivision has its own character.

The astronomical conditions, such as the time of contacts, duration of totality and altitude of the sun, can be calculated precisely for any place. The trigonometry is simple but tedious. A calculating machine is very helpful. The meteorological conditions are not amenable to exact methods but a statistical study of weather reports, when available, is very helpful. The element of pure chance cannot be eliminated but the chances of the game can be estimated.

Some of the conditions classified as "human" can be calculated, some can not. Of course a substantial bank account can open many doors but there are others requiring a pass-word. Since the scientist is best equipped to deal with the "physical" conditions this class will be discussed more intimately.

Before any choice is made one must know the sort of work which is planned. Radio astronomy may be unaffected by cloudiness whereas positional astronomy will imperatively demand a clear but not necessarily a dark sky. If the outer corona is to be studied a thin haze may be as harmful as an overcast sky. The Ottawa group is mainly interested



in the outer corona and will therefore be prepared to sacrifice some other desiderata, and even to suffer severe personal discomfort, in the hope of enjoying a transparent, and dark, sky.

The map of the world (above) has been drawn to illustrate, and help solve, the problems related to the astronomical conditions. The in-

stantaneous position of mid-eclipse has been projected on the "fundamental plane." It is a view of the earth, as seen from the moon, with the features drawn so that all places are properly located at mid-eclipse. The apparent broadening of Africa is caused by the earth turning on its axis whilst the eclipse shadow crosses it. The surface moves in the same direction as the shadow but not fast enough to overtake it. This map can be used to find the time of mid-eclipse for any place near the central line. The cosine of the altitude of the sun can also be found by measuring the distance from the centre of the map in units of the earth's radius. Other details, such as beginning and ending lines, might have been entered on the map but they are not important for planning an expedition. The projection does emphasize the passage of the eclipse from a sunrise to a sunset and the speed with which the shadow must sweep over the foreshortened parts of the earth near the sunrise and sunset circle.

Those observers who want mere freedom from clouds will have little difficulty in selecting a site for their 1952 eclipse camp. The Nile Valley and Arabia are nearly rainless and have a low cloud frequency. The conditions in Central Africa are not known but the west coast is humid and cloudy. So also is Iraq. It has been very difficult to get meteorological reports from Iran, but the British Overseas Airways Corporation has recently supplied a summary which shows that in the mountainous regions on the eclipse track cloud conditions are worse in February than in any other month. Cloud conditions in the Sudan and Saudi Arabia are far more favourable. It is quite possible, however, that some localities on the leeward slopes of the Iranian mountains might be favourable and a camp at 12,000 feet has its attractions, as may be seen later.

The cloud-distribution figures of routine weather reports furnish the primary data for eclipse survey work. Cloudiness is recorded, at set hours each day, on a scale of 0/10 to 10/10, the observer estimating as nearly as he can the coverage of the surface of the earth. Records of cloudiness at a range of heights, if available, can give some very useful additional guidance to eclipse workers because very high clouds are often transparent.

When cloud-coverage figures are reduced to an average there is some doubt about the interpretation. For example what really does the meteorologist mean by, say, "average cloudiness 3.5"? A tabulation showing the number of days, per month, in each class is of much more use. The frequency of the "no cloud," 1/10, 2/10, etc., reports can be established for any period of the year and for any number of years and will not be misunderstood.

Some routine reports also give the "visibility," or the greatest distance at which may be seen a black object, by day, or a light, by night. Since "visibility" measures the amount of fog or haze, in the horizontal direction, these figures are very useful in an eclipse survey.

There is a third criterion, the brightness of the sky, by which the

quality of the cloud-free sky may be judged, with great advantage to astronomy. Unfortunately this has not become a standard meteorological measurment, presumably because this approach has been blocked by lack of suitable instruments.

It would seem that the brightness of the aureole around the sun must be closely related to "visibility" in the horizontal plane, since both result from low-level particle scattering. The diffuse, white light from the zenith must also spring from the same cause and it might be easier to measure because the instrumental interference set up by direct sunlight would not be so troublesome. For the benefit of students of the outer corona it is very much to be hoped that, in the near future, brightness measurements will be made along the tracks of forthcoming eclipses.

In order to know what makes a good, dark, sky during a total eclipse it is necessary to consider how sunlight is diffusely scattered in the atmosphere. There are two types of process recognized. First, colour-selective or "Rayleigh" scattering, when the brightness varies inversely as the square of the wave length, caused by molecules and producing the blue sky. Secondly, white-light scattering, caused by reflecting particles and producing the distance-haze and the bright horizon of the cloudless sky. The particles may be water droplets, smoke, or dust. Both types of scattering are multiple. A ray of light from the sun, after encountering a molecule or a particle loses only a small fraction of its energy, but the scattered light in turn encounters molecules and particles, and this process is repeated many times, over long distances. The diffuse light of the sky is thus built up by primary, secondary, and many higher order scatterings. Reflections may also occur any number of times at the ground or the surface of clouds.

During a total eclipse the direct light is cut off, so there is no primary scattering, but the secondary and higher order processes continue, touched off as it were by the primary scattering at places far enough away to be out of the full shadow cone. That is why the quality of the "clear" sky is of very great importance to the eclipse observer. The brighter the sky the less will be seen of the faint outer corona and the weaker will be the contrast of the fine detail of the rest of it.

Aircraft, flying above the haze level, have been used for eclipse observing; but the motion sets a limit to photographic exposures and the inherent scattering in rapid lenses more than offsets the improvement in the atmosphere, so there is little opportunity for photographic study of the outer corona. The photoelectric techniques which have been developed during the past few years might give useful results.

Since the track of the 1952 eclipse crosses high land, very careful consideration has been given to the possibility of finding favourable conditions at high altitudes.

Owing to its molecular origin, Rayleigh scattering can be expected to decrease slowly with height: in proportion to the mass of air remaining above the observer. White-light scattering should fall off more

rapidly because there is a limit to the height to which many particles can be lifted in a turbulent atmosphere. In many places there is a distinct "haze level," reported by airmen, above which the air is very clear.

The only available report of brightness measurement during the ascent of an aircraft came from the High Altitude Observatory, Climax, Colorado, where a special instrument has been made for measurement of the aureole. Records of two flights made with this instrument were obtained. These confirm the expected slow decrease in Rayleigh scattering above the haze level and away from cloud. A special flight was made by the R.C.A.F. during last August, carrying a small colour measuring photometer, turned towards the northern sky. This flight, on a clear day, shows a strong surface effect, fading out in the first thousand feet, followed by a steady decline in brightness, without appreciable colour change, roughly proportional to the residual atmosphere.

Unfortunately there is nothing to indicate whether surface effects would be smaller for an ascent starting from a greater height above the sea. Further flights have been offered by the R.C.A.F. and a much improved photometer is now available at the University. If the political outlook and the local weather permit the project to be completed some interesting results may be expected.

The manager of the Saudi Arabian Mining Syndicate has supplied a series of daily measurements made last February, at Mahad Dahab, elevation 3250 feet, forty miles from the central line of the eclipse track. His meter has not been calibrated and should not be relied on for absolute measurement of sky brightness, but it does show that some days, classified visually as "clear," are 20% better than others in the same class. There are no records for this place made by a trained meteorologist but the information gathered suggests about 50% of "clear" days in February, quite frequent "high thin clouds" or dust, and a few overcasts.

Reliable meteorological reports are available for the Sudan. There is least cloud in the Nile Valley but some dust. The best "visibility" reported at regular stations is found at El Obeid but in that district the highest land is only about 3000 feet above sea level. Near the Red Sea, conditions of cloud and visibility become less favourable. One is led to hope that it may be possible to find a site in the Red Sea Hills, north west from Port Sudan, where the conditions are favourable. Reports from Gebeit give some support to this hope.

No measurements with a photometer could be obtained during 1950 in the Sudan but special reports on visibility were secured in February from pilots of the airline operating between Khartoum and Port Sudan. Visibilities of 12 to 20 miles were reported. The haze-top is commonly well defined and between 7,000 and 12,000 feet. On two occasions out of eleven the haze-top was below the peaks, which were further reported to be normally above the cloud level. During the period February 10-March 10, in five years, Gebeit has an average number of 8 cloudless

skies at 0900 hr. U.T. and 18 skies with less than 5/10 cloudiness. During the same period, in six years, the corresponding figures for Port Sudan are 3.7 and 17.9.

By far the most significant reports from Iran concern "visibility." The frequency of visibility over 6½ miles, in the winter months, is reported as more than 95% at Qum and Isfahan. No photometer readings could be obtained from any place near the eclipse track.

It would seem that there is very little particle scattering in the Iranian mountains, and the Rayleigh scattering must be less than at lower levels. Comparing a possible 12,000 feet in Iran to the 5,600 feet available in the Red Sea Hills, one might expect the brightness due to Rayleigh scattering to be in the ratio of 51:65, in the zenith sky. But the altitude of the sun at the time of mid-eclipse will be less in Iran and when allowance is made for the oblique line of sight the scattering along this oblique line should change the ratio to 73:75; a difference so small that it is likely to be more than offset by a higher reflection from the ground, which will certainly be snow covered. The less favourable cloud conditions prevailing in Iran seem to leave no doubt about the choice.

The mountains in Saudi Arabia are not high enough to offer much advantage and the political barriers that surround that country are hard to climb. It would seem therefore that the best chances for observation of the outer corona should be found in the Red Sea Hills of the Sudan.

University of Ottawa, 1950 December 14.

Melanchthon, Inspirer of the Study of Astronomy

With a Translation of His Oration in Praise of Astronomy (De Orione, 1553)

By WILLIAM HAMMER

The reader of this article will, no doubt, be impressed with the fact that there is much theology and little astronomy in it. However, it is of interest in that it indicates that in the early centuries, when science still was very young, astronomy already had taken a prominent place in the minds of the leading intellectuals of the day. Editor.

"Who is so hard and insensible," Melanchthon once wrote to Simon Grynaeus, his former fellow student at the school at Pforzheim and subsequently professor of Greek at the University of Heidelberg, "that he, when looking at the sky and the splendid luminaries, would not admire their changing positions and motions and not wish to know the reasons for all this? Human intellect must be lacking in those who are not impressed by their beauty and by the attractiveness of knowing

more about them. Plato aptly remarks that man was given his eyesight for the sake of astronomy. There is indeed an intimate relationship between the eyes and the stars."*

Like most men of the sixteenth century, Melanchthon (1497-1560) adhered to the Ptolemaic system, while a few followers of Copernicus, among them his colleague Erasmus Reinhold, astronomer and mathematician at the University of Wittenberg, aroused considerable suspicion on the part of several theologians. In his early years at the University of Heidelberg, from which he received the Bachelor's degree at the age of fourteen, Melanchthon was fascinated by the studies of classics and philosophy as well as astronomy. With great respect and deep gratitude he always remembered above all his two professors who taught those subjects: Georg Simler and Conrad Helvetius. When he continued his work at the University of Tübingen, where he obtained the Master's degree in 1514, his interest in astronomy was kindled through the reading of Hesiod and the lectures of the then famous astronomer, Johann Stöffler, who, in line with contemporary thinking, imbued his disciple with the belief that the destiny of man and the course of events were determined by heavenly motions, an attitude which even a sound scholar and profound theologian like Melanchthon never succeeded in discarding entirely (*cf.* the honorable mention of astrology in Isaiah 47:13 and Daniel 2:2 ff.). At Tübingen, upon Stöffler's suggestion in 1517, the young lecturer began his Latin translation of the epic poem *Phainomena* by Aratus (4th century B.C.). Although this work was undertaken in order to acquaint students and learned men with this particular branch of knowledge, Melanchthon, after having completed a portion of it (his edition of the Greek text appeared in 1521), abandoned it in favor of urgently needed critical texts of some of Aristotle's treatises. His major activities in behalf of the Reformation and the training of students belong to the years spent at the University of Wittenberg (1518-1560), where he soon gained the friendship of his colleagues in astronomy, Caspar Borner and Erasmus Reinhold, whose publications enjoyed the benefit of his ever ready advice. Despite the excessive demands on his vast knowledge—his energy and time were consumed by frequent journeys and attendance at meetings—, Melanchthon never lost interest in this subject. His editions of works by ancient and contemporary astronomers, especially during the thirties and the first half of the fifties, his numerous orations on various scientific, literary, philosophical, and theological topics in general and on mathematics and astronomy in particular bear ample testimony of this. Here he spared no effort in the tireless encouragement of the rising generation of university students who approached these two subjects rather reluctantly because of the allegedly inherent difficulties commonly as-

*August, 1531: *cf. Philippi Melanthonis Opera*, in *Corpus Reformatorum*, II (Halle, 1835), col. 530.

The spelling *Melanthonis* here used is that preferred by the writer himself in later years.

sociated with them. On the other hand, there were the humanists whose interests generally revolved around the arts. Adhering to the belief that such scientific topics defied elegant diction, the humanists either ignored or disdained them.

In this connection a brief reference to the significance of the University of Wittenberg in the history of modern thought may be in order. It must be remembered that this unassuming town on the Elbe lay in what might be called "colonial" territory, remote from the main routes of trade and learning, a settlement without leading patrician families and without established ecclesiastical influence, briefly, to speak with Luther, a place on the very borderland of civilization. A town outside the sphere of intellectual supremacy, it became the seat of a university lacking tradition, for it was the first institution of higher learning established without the hitherto customary papal bull of foundation. (The charter of its founder, Elector Frederick the Wise of Saxony, was not ratified by Rome until 1507.) Wittenberg thus set a precedent for the founding of subsequent universities under the protectorate of territorial princes independent of ecclesiastical authority and benefices. Nor should we overlook the fact that from the beginning a department entrusted with the teaching of purely humanistic subjects was officially made a part of the Wittenberg Faculty of Arts which, contrary to the situation at other universities, placed the mediaevalists in a decidedly defensive position. Through the efficient instruction in the three Biblical languages as well as their religious and secular literatures, this seat of learning attained an unusually strong position during the early years of its existence. The fresh impetus which the study of theology received through the influence of the Reformation soon made itself felt in the other faculties, particularly that of the arts. There is no doubt that Melanchthon was not only the soul of this university but also the source of inspiration for the many academic subjects then taught. Already through his memorable and lofty inaugural lecture (August 29, 1518, four days after his arrival at Wittenberg), in which he presented a new program on the improvement of the studies of youth (*De corrigendis adolescentiae studiis*), to a receptive and highly impressed audience, this young scholar at the age of twenty-one started a career which almost immediately led to his intellectual leadership in the university. There was no room for departmentalization. Endowed with an extraordinary knowledge and memory, and almost unbelievable industry in spite of his very precarious health, he lectured competently on a variety of subjects, wrote grammars, letters, and orations (often delivered by others), edited dozens of works, and drafted prefaces for editions published by his friends, colleagues, and printers. His monumental achievement is now embodied in the 28 quarto-volumes of the *Corpus Reformatorum* with one supplement and in the seven sections (some consisting of several parts) of the *Supplementa Melanchthoniana*. He was equally concerned about the reorganization of the universities and higher edu-

cation in general; as a consequence he drew up the laws and statutes for the faculties of theology and the arts which were adopted by the German universities founded during his life time and afterwards. It is ultimately through the efforts of this *Praeceptor Germaniae* to which scholarship owed its Melanchthonian thoroughness and reputation which, in turn, exerted a strong influence on the universities of other countries.

We must take cognizance of these facts in order to understand and to appreciate the different tenor and seemingly unusual spirit which speaks from the humanistic writings of Melanchthon. For in them we have an illustration of his fundamental principle that all learning and knowledge is interrelated, that the liberal arts and science must be viewed in connection with God's plans and His Word, that true theology is possible only after and with a reasonably thorough familiarity with philology, philosophy, and science, in brief, that the foremost objective is to convey ethical values. Melanchthon's intellectual brilliancy and universality as well as his extensive literary, academic, and pedagogical activities undoubtedly deserved the unqualified admiration of his contemporaries and should elicit this no less from all generations. He, the humanist among the reformers, who was averse to political and intellectual upheavals, constant distractions, and unrewarding struggles, saw his major objective in the promotion of peace and learning for the glory of God and in the life of a teacher, reformer, and organizer ("through the school and for the school"). No wonder that as early as March 1, 1537, he wrote to his life-long friend and subsequent biographer, Joachim Camerarius: "these unintellectual affairs deter me, I don't know by what destiny, from my studies and from a mode of life which I prefer to anything else, nor do I see how we can benefit by them. . . . The task of training our youth seems to me to be the most profitable and most pleasing. Would to God that the circumstances of the time might not prevent me from fulfilling this mission!"

Outside of Germany and apart from theologians and literary historians familiar with classical languages, the writings of Melanchthon are still relatively little known due to the lack of translations into various modern languages. The following oration on Orion which I present in an English rendition occupies, I believe, a singularly noteworthy position in the history of ideas, for Melanchthon's repeated eulogistic references to mathematics and astronomy foreshadow a perspective across the centuries. In a way they herald the great philosophers and mathematicians of the era of enlightenment: Descartes, Leibniz, and Christian Wolff, the last, significantly perhaps, professor at what in 1817 was to become the United University of Halle-Wittenberg.

ORATION ON ORION

WITH A COMMENDATION OF THE STUDY OF ASTRONOMY AND A REFUTATION OF THOSE WHO CENSURE, VITUPERATE, AND HAMPER THESE STUDIES THROUGH UNJUSTIFIED SLANDER.[1]

Recited by Matthew Blochinger

Although many testimonies have come down to us which show that the Church is saved, preserved, and protected by the Son of God, even without man's assistance, yet a particularly noteworthy example is the presence of the Son of God in the flames of the Babylonian furnace, where the king asserted that, apart from the three men cast together into the fire, he saw a fourth of a more venerable appearance whom in fact he also called the Son of God.[2] Just as He then protected those three in the fire, thus He always defends the church universal against the raging devils and their accomplices, even though not all are aware of the dangers. We, however, have seen manifest examples of this for quite some time.

First, therefore, I give thanks unto the Son of God, our Lord Jesus Christ, Who amidst these disorders of empires has brought together the Church in this region and protects us in our manifold tribulations without allowing the light of the Gospel to become extinguished. Him I request with ardent prayers that among us teachers and students He may always serve and govern our course so that He be truly praised. We notice that in this disaster of dominions the churches are severely shaken and men carried away indiscriminately. Let us heed these public evils in order that we may consider the study of His teaching with greater care and that our prayer be more fervent.

Since we speak in these academic assemblies either on historical matters or present some theme dealing with the arts, from which youth is likely to benefit, I have chosen a subject which combines history with advice, and is thus valuable for young students; just as others have spoken about various outstanding figures, so shall I about time-honored Orion. Although I think I can avoid false information regarding this old topic,[3] I nevertheless fear the censure of certain people. But, as that brave leader Pausanias said: "To please the Spartans it is sufficient for me to say and do what is right,"[4] so we shall consider and follow

[1] The original Latin text is printed in *Corpus Reformatorum*, XII (Halle, 1844), cols. 46-52.

[2] King Nebuchadnezzar, see Daniel 3:24 f.

[3] For the various ancient legends associated with Orion, see the detailed account in W. H. Roscher, *Ausführliches Lexikon der griechischen und römischen Mythologie*, III, pt. i (Leipzig, 1897-1902), cols. 1018-1047. Isidore of Seville (*ca.* 560-636), whose work *Etymologies* was a widely used reference book for many subsequent centuries, briefly reported on this subject (*cf.* 3, 71 §§ 10-14).

[4] Pausanias, Spartan general in the battle against the Persians at Plataea, 479 B.C. He had been accused of planning to make himself ruler of all Greece with Persian aid; in 470 or 469 he sought refuge in Athene's temple in Sparta where he died. His biography was written by Cornelius Nepos (*ca.* 100 B.C.—*ca.* 32 B.C.), *De excellentibus ducibus exterarum gentium*. I have found no source for the above quotation.

the judgment of the learned and wise. Thus I am going to speak about Orion in order to be a guide and counselor to young people, in the first place that they may observe this and other constellations in the skies, because, to do this willingly and often, the very beauty of the stars *must* attract them. Furthermore, that they, at the sight of these beautiful luminaries, may meditate upon the entire arrangement of the year and upon the reason why God, the Author of all, created differences in seasons and annual cycles. And finally, that at such contemplation they may acknowledge God as the Creator and praise His wisdom and goodness shining forth from the infinite variety of blessings by which He shows His care for mankind. May they also realize that the wise and just Creator has shed the rays of His light upon us, namely, in order to distinguish between the concepts of good and evil, which He wants to be the rule of life; to bless those who obey Him; but, on the other hand, to wreak dreadful destruction upon the obdurate. You know that this contemplation of the nature of God and the reflection upon His wisdom, goodness, and justice are exalted in the first chapter of the letter to the Romans. For this reason there is no doubt that the sky is so adorned with beautiful lights, and likewise the order of the revolutions is so skillfully planned that through this very beauty and order we are invited to such observation. As I said, I shall speak about Orion, *i.e.*, about the constellation itself, its name, and the legends about it in the works of ancient writers.

Not in great detail, but nonetheless to instruct the uneducated, Homer distinguished between two celestial hemispheres, the northern and the southern. In the northern, where he placed the top of the heavens or, as we call it, the pole, is the Bear, in the opposite part Orion,[5] between the Bull and the Twins. What the entire constellation is like can best be learned by looking at the sky. Since the position of the stars represents the shape of an armed man, the poets imagined this man to have been placed among the stars, and by this name and its history they exhibited something about the rising and setting of that constellation. Nor is it doubtful that this constellation received its name from the originator who arranged the year for the Greeks and disseminated the elements of astronomy,[6] just as many other stars were given the names of leaders and teachers who examined the various phases of the year. Thus were translated to the sky Perseus, the daughters of Atlas,[7] Astraea,[8] the

[5] Homer distinguishes clearly between Orion the legendary hero and the constellation; for references to the latter see *Iliad* 18, 486, 488 (identical with *Odyssey* 5, 274), *Iliad* 22, 29.

[6] Thales (*ca.* 640-587), the father of Greek astronomy.

[7] The Pleiades and the Hyades. According to legend Atlas himself was much devoted to the study of astronomy.

[8] Astraea, the goddess of justice, living on earth during the Golden Age but placed among the stars because of the growing evil of man; as a constellation identified with Libra and Virgo. Generally Astraea is not mentioned as a daughter of Icarius.

daughter of Icarius, Chiron the Centaur,[9] the Lyre of Orpheus, Hercules, Castor, Pollux, and Cepheus whom I believe to be Kittim.[10] Pausanias states that Orion had been a Boeotian prince and that at Tanagra the place was shown where Atlas instructed Orion in the laws of the stellar motions.[11] Because of his zeal for this instruction, he is said to have loved Aurora or Diana, *i.e.*, Luna.[12]

It may be that posterity transferred the name of this well-deserving hero to a most beautiful constellation in order to hand down the memory of this teacher [of astronomy] to many generations. But the poets adapt the name to the nature of the constellation. They say[13] that Orion originated from the urine of Jupiter, Neptune, and Mercury. For this reason, when he set the winds in motion and brought rain, the name happened to become identical with *uron* (*ουρον*), *i.e.*, urine. The humidity they derived from Neptune, *i.e.*, from the vapors of the sea which, condensed in the air and called Jupiter [Pluvius], constitute rain. But Mercury also moves and impels the clouds. Hence the descriptions in the works of natural philosophers and poets, as in Virgil, in the first book of the *Aeneid*, "when rainy Orion rose with a sudden surge,"[14] and in the seventh, "when fierce Orion plunges down in the wintry waves,"[15] or when Aristotle declares "Orion is indeed said to be recalcitrant whether rising or setting."[16]

The unanimous experience of all ages bears witness to this conclusion, and last year we saw that because of the conjunction of Jupiter and Mars in the constellation of Leo there was a great drought from July to November; there were dry winds, and suddenly a considerable change in the air and heavy rain appeared when Orion was setting. Nor do I doubt that among the Hebrews November was given the name Kislev, which occurs in Zechariah[17] and in the books of the Maccabees,[18] after Orion whom they call Kesil, because of the changing

[9] Chiron, one of the Centaurs, son of Saturn and Philyra, renowned for his knowledge of plants and medicine, and for his divination.

[10] Kittim (Gen. 10:4; 1 Chron. 1:7), son of Javan and grandson of Japhet. In Greek mythology Cepheus was an Ethiopian king, husband of Cassiopeia and father of Andromeda. All three became constellations.

[11] Tanagra in Boeotia is the legendary place of Orion's death. *Cf.* Pausanias, *Description of Greece*, IX, 20, 3. The author, a Greek from Asia Minor, wrote this travel guide between 160 and 180 A.D.; it is the chief source of the history of ancient art and of the topography of Greece.

[12] For the involved legendary additions see Roscher, *op. cit.*, cols. 1040-1044.

[13] Ovid, *Fasti* 5, 495 ff.

[14] Vs. 535.

[15] Vs. 719. Melanchthon might have added *Aen.* 4, 52; "while winter (or, stormy weather) rages furiously at sea and Orion is rainy."

[16] *Problems* 26, 13 [= 941[b], 24 ff.] also in *Meteorologica* 2, 5 [= 361[b]]. The continuation of Aristotle's statement is worth quoting because of the symbolic significance for Melanchthon's own time: "because of the indefiniteness of the season: for it must be a time of disturbance and irregularity."

[17] Kislev (Chislev) is the ninth month of the Jewish ecclesiastical year; Zechariah 7:1.

[18] 1 Maccab. 1:54; 4:52, 60; 2 Maccab. 1:10, 18; 10:5.

weather, I suppose.[19] It has often come to my mind that this word was orion [ωριων] because of the division of the year into four seasons which are called *horai* [ωραι].[20] The beginning of spring occurs at the heliacal setting of Orion, the beginning of summer at the heliacal rising, that of winter at the cosmic setting.[21] Even the people noticed this with their own eyes, since the approach of the sun to certain stars or constellations which were most conspicuous constituted the seasons of the year, and at the same time they learned that seasons changed according to the rising and setting of various stars. To their setting belongs also that men of old imagined Orion had been killed by Scorpion.[22] "What is the use of pondering over such matters," some people say and quote this Pindaric statement: "it is fruitless wisdom which natural philosophers gather."[23] We do know the inane opinions of many. But first we hold against these the Divine Word which speaks of Sun, Moon, and the Stars. They will be for signs, seasons, days and years.[24] For many weighty reasons God wants the times of the year, their difference and sequence to be known, namely, for us to realize that God alone in ages

[19] The real etymology and the meaning of the word *Kesil* (*Chesil*) are unknown. Hebraists have advanced various suggestions.

[20] Melanchthon probably thinks of ωρα and ωρος with which the word *year* and other Germanic equivalents supposedly are related.

[21] Orion rises heliacally just after the time of summer solstice, its rising and setting being followed by storms. The heliacal rising of the Pleiades marks the beginning of summer, their setting that of winter. In his *Works and Days*, Hesiod clearly refers to stars and seasons, especially to Orion, Sirius, the Pleiades and Hyades (*cf.* vss. 598, 609 ff., 614 ff.). (Melanchthon's statement is not entirely clear. It seems that, if for *spring* we read *summer*, and if for *cosmic setting*, we understand *setting at sunrise*, the astronomical facts are fairly correctly represented. Ed.)

[22] The legend of Orion's death by Scorpion apparently had its origin in the observation of the two constellations, *i.e.*, the almost simultaneous rising of Scorpion and the setting of Orion (and *vice versa*). Just as the early setting of the Pleiades was interpreted as a flight from the hunter Orion, so Orion's retreat from the rising Scorpion started the myth (Hesiod, *Astronomy*, 8th cent. B.C., as reported in *Katasterismoi*, fragment 32, a collection of sidereal legends attributed to Eratosthenes, *ca.* 275—*ca.* 195 B.C.) that on earth both had been irreconcilable enemies. The first authentic evidence of this legend, current on the islands of Crete and Chios, is extant in the well-known didactic epic poem *Phainomena* (vss. 634-646) by Aratus (b. *ca.* 315 B.C.) who relates the events free from mythological interpretation. He concludes his version with these words: "Therefore, people say, when Scorpion rises from the far side [the East], Orion flees to the uttermost parts of the earth [the West]." References to this legend are frequent in Greek and Latin literature.

[23] Apparently the corresponding Greek phrase quoted by Melanchthon does not represent the original wording. My colleague, Professor Charles Rayment, kindly called my attention to a Pindaric fragment of similar content ("to gather the futile harvest of knowledge"): *cf. Pindari Carmina cum Fragmentis*, ed. C. M. Bowra (Oxford, 1935), fragm. [incerti loci] 197. According to Bowra's note, the statement appeared in Johannes Stobaeus (*ca.* 500 A.D.): "Pindar says that those who investigate natural phenomena gather a futile harvest of knowledge." Melanchthon's comments on Pindar and Stobaeus reveal his familiarity with these writers.

[24] It is interesting to note that, except for the verb, Melanchthon does not follow the wording of the Vulgate in his Latin quotation but gives a Latin retranslation of Luther's German text which, unconsciously perhaps, must have been in his mind at the time of writing.

past existed from all eternity and that in fact these bodies of the universe were at that time created by Him spontaneously as it pleased Him. And in order that we may understand the beginning, a distinction of years was made which determined a period of time. Then He also wants it to be known that our human race will not be eternal, but that a limitation has been set which is not far off, when life will be restored to the dead, the Church extolled in eternal glory, and the wicked cast away into everlasting torments.[25] Although we do not know what year and day the trumpets of the angels will announce the beginning of His triumph,[26] God nevertheless foretold that the interval between Christ's resurrection and ours will not be long. Neither is the statement attributed to Elijah to be disregarded: six-thousand years the world will stand and thereafter comes the conflagration: Two-thousand years of chaos, two-thousand of the Law, and two-thousand the days of the Messiah.[27]

Hence, if a number of years will be lacking, it is because of our manifold sins. Now that 5515 years have passed since the creation of the world, we certainly are not far from the day of His triumph, when the Son of God will again present Himself to all mankind and His Father publicly to His Church. Furthermore, it should be noted that a sequence of years is all the more necessary in order that we may know what the oldest teaching among the human race is, when and on what evidence promises were transmitted, at what time the Son of God was to assume human nature, and which might be the future succession of empires and, finally, how much obscurity there would be in public life, in history, agreements, and decisions, if there were no distinction according to years. For these many reasons God instituted this and wanted it to be observed. Though we should realize this because of numerous advantages, yet we ought to cherish it all the more as there is in these motions an admirable ingenuity, itself a unique testimony of God. In view of this fact, remember what a great crime it is to scorn this magnificent wisdom of God and to deter men from the contemplation of the Divine. For this malice our authorities should inflict public punishment. However, some subtle people will answer that they do not condemn the study of the celestial motions but merely their divination. This pretext is nothing but a convenient subterfuge, hence something else on their part.

[25] *Cf.* John 5:28 f.

[26] *Cf.* Matth. 24:30 f., 25:13.

[27] This is strongly reminiscent of mediaeval chronicles. In view of Elijah's prophetic mission, the rise of innumerable legends of Jewish and non-Jewish origin is quite understandable. This one, however, does not figure among the Apocrypha or Pseudepigrapha of the Old Testament. To some extent this notion, current throughout the Middle Ages, is based on Daniel's interpretation of Nebuchadnezzar's dream; *cf.* Dan. 2:37-44. References to these periods of world history are also found in Melanchthon's *Chronicon Carionis* (German text, 1531; Latin revised and enlarged version, 2 books, 1558-1560; books 3 and 4 appeared after his death; *cf. Corpus Ref.*, XII, cols. 705 ff.). This *Chronicon*, a very learned work and a widely used handbook on history, passed through 35 editions until 1624.

For they know what predictions we may examine. They realize that we clearly discern physical causes with references to God, to the free choice of the human will, and to devilish impulses. Is it a crime to say that the air is warmed through the light of the sun, that a more direct ray from the sun in summer has greater heating power, and that the moon is cold? Rather is God's power and wisdom evident when these qualities of the celestial lights are considered in an annual cycle. Such is the course of the sun among the other stars that the characteristics within single intervals are adapted to the usefulness of nascent matters. The Ram is drier,[28] so that the soil saturated with ice and rain be less wet and is thus made suitable for the seed. Later, when the crop grows and needs moisture again and when the sun rises to the Pleiades and Hyades, the rain-bringing stars pour forth showers; then the sun proceeds through the temperate constellation of the Twins and with a mild warmth promotes the growth of everything.

When it approaches Cancer and Praesepe,[29] rain is needed again when grain is formed in the ears, but dryness, on the other hand, for the harvest. The heat, accordingly, is greatest when the sun approaches Sirius. This happens more or less regularly because of the orbits of the planets; nevertheless, God governs this whole procedure by His free will. In all His handiwork He participates in a favorable manner, but because of man's wickedness He aids even good qualities to a lesser degree, and for the sake of His Church he often prevents evil. And yet, we must admit that there is ingenuity in the shaping of things. Not without definite reason has the alternation of summer and winter been instituted, for God wants that there be an interval during which the soil after having received the seed may have rest and moisture. Thus the position of the sun deviates so that the rays strike us in the right way. God, however, does not depart from His work but watches over the sun, the earth, and mankind, and either promotes or checks the influence of the sun through His free decision. Thus, with all our heart we confess that His judgment is right. In God we live, we are and move.[30] "He is thy life and the length of thy days,[31] and also "Man doth not live by bread only, but by every word that proceedeth out of the mouth of the Lord."[32] However, I am not going to speak now in particular about the controversy as to what the influence of the stars might be, which predictions may be approved and which rejected. That has been calmly discussed elsewhere.[33] This true divination should always be before our eyes, *viz.*, that the fixed order of the motions of sun and moon, instituted for the benefit of everything living, is an illustrious testimony of

[28] *I.e.*, does not set beneath the sea.

[29] The Beehive, a star cluster in the constellation Cancer.

[30] *Cf.* Acts 17:28: "For in Him we live, and move, and have our being."

[31] Deut. 30:20.

[32] Deut. 8:3; *cf.* Matth. 4:4; Luke 4:4.

[33] In his oration *Dignitas Astrologiae* (1535); see *Corpus Reformatorum* XI (Halle, 1843), cols. 261-266.

God showing thereby that this world was not composed by chance from the atoms of a Democritus but created and preserved by the mind of a master-planner. To recognize God the Creator from the order of the heavenly motions and of His entire work, *that* is true and useful divination, for which reason God wanted us also to behold His works. Let us therefore cherish the subject which demonstrates the order of the motions and the description of the year, and let us not be deterred by harmful opinions, since some—rightly or wrongly—always hate the pursuit of knowledge. And perhaps those who imagined that Orion had been killed by Scorpion did not so much intimate rise and fall, that Scorpion upon rising killed Orion, but also pointed out that men desirous of learning are oppressed by the deception and malice of the wicked, as Socrates was maligned by Anytus and Melitus.[34] All this is customary in human life and must be borne judiciously.

I shall not say what else Orion signifies except the storms according to Virgil's verse already cited: "when rainy Orion rose with a sudden surge." Manilius[35] declares that to men Orion means labor and wandering about when he states: "It will be an image of the people and will dwell in the entire world." But I can in no way vouch for this interpretation. Let us be satisfied with the natural suggestion about the seasons and let us not think that a study of this kind is to be scorned. For we know that the Church is not guided by the realm of the stars; but beneficial government is carried out by the Son of God, the Protector of the Church, when He says: "I am the vine, ye are the branches."[36] The devils, however, disturb her and employ tools whose minds and temperaments are corrupted by poison. And yet, in the sky God has represented the likeness of certain things in the Church. Just as the moon receives its light from the sun, so light and fire are transfused to the Church by the Son of God. Our knowledge of God is kindled by the word of the Gospel, the Holy Ghost inflaming the love of God and other beneficial affections. It is conceivable that there are images of many things in the sky. Just as Orion pursues the Pleiades as if to catch them,[37] so the dominions of the world persecute an unwarlike church. When the Son of God was hanging on the Cross, the sun was darkened[38] between the Pleiades and Orion.[39] Thus, in the last days the raging of earthly powers will be greater and the darkness in the Church sadder.[40] About this we have, however, other admonitions entrusted to us by the express word of the Son of God, through the meditation of which we should be moved to be all the more eager in the study of His

[34] Generally Meletus; he and Anytus are two of the three accusers of Socrates.

[35] Marcus Manilius, author of the didactic poem *Astronomica* (written about the end of the reign of Augustus); *cf.* V, 64.

[36] John 15:5.

[37] Hesiod, *Works and Days*, 619 f.

[38] *Cf.* Luke 23:45.

[39] It is difficult to ascertain a source for this addition.

[40] Reminiscent of 2 Tim. 3:1 ff.

teaching and in prayer, as the Son Himself in His agony commanded His Apostles: "Pray that ye enter not into temptation.[41] Few like this kind of study, and there is great dissimilarity among those who learn. Many fanatics contrive wicked doctrines with dreadful furor, and thus darkness increases. Let us watch these evils, and may we seek, cherish, and defend the truth with even greater concern. With all my heart I pray that the Son of God guide and help us in this. I also pray that He mitigate the punishment and for all time bring closer to Him, govern, and protect the Church in these lands. And herewith I close.

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[41] Quoted from Luke 22:40; *cf. ibid.*, vs. 46; Matth. 26:41; Mark 14:38.

Contributions of the Meteoritical Society

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The "Josiah" and the "Joshua Bates" and the Meteoritic-Dust Shower of November 14, 1856

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ABSTRACT

Thru loose misquotations made some 25 years after the originally published facts in regard to the important shower of meteoritic dust that fell onto the ship *Joshua Bates* on November 14, 1856, the misconception has arisen that *two* such showers had been observed, the second in 1859. It is here shown that all of the references involved correspond to one and the same shower.

In John Davis Buddhue's "Meteoritic Dust" (*University of New Mexico Publications in Meteoritics*, No. 2, 1950), the "Historical Review" (pp. 12-22) notes two apparently similar events that the author concludes to be separate incidents, in spite of several outstanding coincidences. The first of the two refers to a shower of meteoritic dust that fell onto the ship *Joshua Bates* in 1856; the other to a similar dust-fall on the *Josiah Bates* in January, 1859. Thanks to an extensive bibliography on meteoritical literature kept by the late Dr. Willard J. Fisher (1867-1934) at Harvard, I believe it can be shown that the two accounts to which Buddhue refers correspond to one and the same fall of meteoritic dust on the ship *Joshua Bates*, on November 14, 1856. The original publications on this subject are not readily accessible; hence, the confusion in dates and in the ship's name seems to have arisen thru the use of secondary references in which inaccuracies do occur. For the sake of those readers who may not have Buddhue's booklet at hand, I first quote the passages in question (pp. 12-13):

"**1856**. von Reichenbach (85) states that black particles the size of birdshot fell on the ship *Joshua Bates* after the passage of a meteor. The location of the ship was 450 km. south of Java at latitude 10° 38′ S., longitude 117° 49′ E. This account was published three years later, in 1859.

"**1859**. Ehrenberg reported that a fine dust settled on the ship *Josiah Bates* on January 25, 1859, while in the Indian Ocean. This dust was found to consist of metallic iron and iron oxide 'solidified and creased in a manner analogous to the Batavian Tears' (23).

"Were it not for the different dates of fall of these substances, and the apparent difference in particle size, one would be tempted to regard this and the previous note as variant accounts of the same incident. This is suggested by the nearly identical names of the two ships, the similar geographical position, and the fact that the publication date of Reichenbach's account coincides with the year of the second incident."

Fisher's card catalog contains a section of about one hundred cards on material relevant to "Meteoric Dust." They include 6 references to the *Joshua Bates,* of which Buddhue cited but 2 (Nos. 2 and 5 listed hereafter). Altho I have not had personal access to all of the articles to which reference is made, the abstracts and comments Fisher recorded may suffice to show that only the one ship, the *Joshua Bates,* and the one shower, of November 14, 1856, are concerned. I have not, however, been able to account for the source of the quotation of date January 25, 1859, unless that happens to be the precise date of publication of Ehrenberg's report.

The 6 references I list chronologically, together with brief abstracts of the articles, to the extent that they have a bearing on the *Joshua* (or *Josiah*) *Bates* samples of atmospheric dust.

1. *C. G. Ehrenberg,* ". . . über einen Niederfall von schwarzem, polirten, und hohlen Vogelschrot-Körnern ähnlichen atmosphärischen Eisenstaub im hohen Süd-Ocean," *Monatsbericht d. K. Ak. Wissen.,* Berlin, aus dem Jahre 1858, pp. 1-10, 1859.

Lt. Maury had sent Ehrenberg a sample of atmospheric dust that had fallen onto the American ship *Joshua Bates* (Captain, D. S. McCallum), on November 14, 1856. Lat. S. 10° 38′, long. E. 117° 49′. Gives description, especially of spherules (largest 1/6 to 1/3; generally smaller, 1/25 to 1/40 Paris line). Thinks they may be of volcanic origin, altho attracted by a magnet, as is not the case for samples of known volcanic dust he had available.

2. *K. von Reichenbach,* "Die meteorischen Kügelchen des Capitain Callum," *Pogg. Ann.* (4), **16**, 476-90, 1859 (Whole No. 106).

Argues against Ehrenberg's volcanic theory for explanation of the spherules. Showed "that the hardness of McCallum's spherules agrees

(85) F. von Reichenbach, *Pogg. Ann.*, **16**, 476-90, 1859.

(23) A. Ditte, *Revue scient.* (5), **2**, 709, 1904; reprinted in *Ann. Rept. of the Smithsonian Inst.*, pp. 235-44, 1904.

with that of the crust in iron meteorites. Concludes that the Fe_3O_4 dust of a great iron or iron-rich meteor had fallen upon the deck of the *Joshua Bates,* and that the sample submitted to Ehrenberg showed what the train of such a meteorite consists of." Thus, von Reichenbach's report, to which Buddhue refers, is not the original account of the 1856 rain of meteoritic dust, but rather a rebuttal to Ehrenberg's conclusion as to its origin.

3. *E. Heis,* "Meteorische Kügelchen des Capitain Callum," *Wochenschrift f. Astron. usw.* (N.S.), **2**, 319-20, 1859.

Discussion of a report by Ehrenberg in *Monatsbericht,* Berlin, Jan. 4, 1858, in which Ehrenberg concluded that the particles are not of meteoritic origin but ejecta of a Javanese gas volcano, carried to sea by the wind. On the other hand, v. Reichenbach (*Pogg. Ann.,* No. 3, 1859) regards the spherules rather as evidence of a fireball.

4. *S. Meunier,* "Météorites," pp. 307-8, 1884, Paris, in "Appendice: Poussières, liquides, et gaz d'origine météorique."

Stated that on the night of January 24-25, 1859, the *Josiah Bates* (Captain McCallum) was showered with a fine dust. Samples of this were sent to Lt. Maury in Washington, who, unable to account for its origin, sent a sample to Ehrenberg. Fisher refers to Heis, "who gives different dates; 1859 is surely wrong."

It would seem indeed that too many coincidences are involved between this and the previous references to accept the January, 1859, dates as authentic. Moreover, if another fall of dust had occurred, of which samples had been collected and analyzed by exactly the same people involved in the case of the 1856 sample, a direct comparison of the two events would unquestionably have appeared in the literature. Note that the date of Meunier's treatise is 1884—25 years after that of the reputed rain of dust he describes. I do not have available a copy of this treatise from which to check Meunier's references, but, if he had cited any between 1859 and 1884, Fisher would, presumably, have incorporated them in his catalog.

5. *A. Ditte,* "Metals in the Atmosphere," *Annual Report of the Smithsonian Institution,* pp. 235-47, 1904. This is a translation of "Les métaux dans l'atmosphère," a lecture of the Faculty of Sciences of Paris, delivered Nov. 9, 1904, and published in the *Revue scientifique,* Paris (5), **2**, 709, Dec. 3, 1904.

Fisher comments: "The whole is really a rather poorly translated abstract of G. Tissandier's 'Les poussières de l'air'; *cf. Ciel et Terre,* **25**, 525-7, 1904."

Ditte's paper does not indicate specific sources for the information given. In view of their common errors, it may well be that Meunier's treatise was Ditte's source of information—an inference enhanced by the fact that both authors were Frenchmen and that Ditte did quote Meunier in another connection. Buddhue, in turn, accepted Ditte's account as given in the *Smithsonian Report.*

6. *F. C. Bowen,* "A Century of Atlantic Travel," pp. 40 & 46, 1930, Little, Brown, & Co., Boston, on the clipper ship *Joshua Bates*:

"First ship of what was afterwards to be the White Diamond Line," 620 tons, "far in advance of any other packet of her day."

If there had been two ships of such similar names as *Joshua* and *Josiah Bates* it is very likely that both would have been mentioned in this book; but that both should have had captains named McCallum seems much too improbable!

Thus, too many coincidences are involved among the various references to permit any conclusion other than that the two items in question refer to one and the same material, and that the error originated presumably with Meunier, whom Ditte probably used as his source.

It may be noted also that the *Jung* to whom Buddhue refers on p. 18 (*op. cit.*) is *E. Yung;* this spelling also is traced to Ditte's paper. I happen to have 4 references to Yung's investigations of atmospheric dust, only one of which refers but briefly to the snow storm of 1883 and the results that both Ditte and Buddhue describe; it is "Chute de poussières cosmiques" (*Compt. Rend.,* (2), **97**, 1449, 1883). Fisher's card catalog cites 2 earlier references: "Du fer météorique" (*Compt. Rend.,* (2), **83**, 242, 1876) and "Étude sur les poussières cosmiques" (*Bull. Soc. Sci. et Nat.,* Neuchâtel, **14**, 493-506, 1876; *Archives des Sci. Phys. et Nat.,* Genève, **61**, 252, 1878), both of which relate to Yung's analysis of dust samples from snow in 1874-76. I have found, in addition, an interesting note in the reports on the great Andromid meteor shower of November 27, 1885 (*Astron. Nachr.,* **113**, 139, 1886), during which from 600 to 1000 meteors a minute are said to have been seen. Rain that fell in Gent (Belgium) on November 28, 1885, and on the following few days was analyzed by Yung, who found that it contained meteoritic particles. It was, moreover, reported that sections of "clear" sky between the clouds at about 5:30 P.M. on November 29 and 30, 1885, were colored, reminding observers of the colored sunsets following the eruption of Krakatoa in 1883. The suggestion was offered that the spectacular meteor shower of November 27, 1885, might have left in its wake meteoritic dust in the atmosphere sufficient to account for similar sunsets.

Experiments on the Etching of Siderites

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ABSTRACT

A number of old and new etching reagents for meteorites have been tested. None was found to be superior to those already in general use, except that the recent report that the addition of a little *glue* gives improved results is confirmed. Some other colloidal additives also were found to give a better etch, but none was better than glue. A few other experiments also are briefly mentioned. All workable reagents give the same kind of figures.

O. C. Farrington[1] lists a number of reagents that have been used to

etch iron meteorites, and says that "The figures obtained with some of these agents are said to differ from those obtained in other ways." If this statement were true, then meteoriticists might have overlooked a valuable source of information. The following experiments were made partly to prove or to disprove this statement of Farrington's.

I have found few references to etching reagents other than the usual nitric acid diluted with water or alcohol or both. The first to use nitric acid appears to have been G. Thomson in 1804. He worked with the Krasnojarsk, Yeniseisk, Siberia, pallasite and published some of the figures obtained.[2] It will be noted that this publication antedates the independent discovery of the effect of the differential oxidation produced by heating a siderite, attributed to A. J. von Widmanstätten in 1808. I recall also one or two references each to the use of fuming nitric acid and alcoholic picric acid, in addition to the reagents listed by Farrington. Foote[3] has mentioned that the figures on a polished unetched specimen can be momentarily revealed by breathing onto it. As a matter of fact, the structure can be seen on a polished surface sometimes without any treatment. The most recent innovation was the accidental discovery that the addition of a little *glue* to a dilute solution of nitric acid in a mixture of water and alcohol considerably improves the etching qualities of the latter.[4]

I heard of B. O. Reberholt's discovery[4] *via* the "grapevine" before its publication, and it was partly responsible for my undertaking these experiments. I had, however, long ago tried ammoniacal copper sulfate (mentioned by Farrington) and alcoholic picric acid, and had repeated the work of Widmanstätten with specimens of Canyon Diablo, Arizona, and Xiquipilco (Toluca), Mexico. The results obtained with heat were excellent. The new experiments were made on a slice of a Henbury, Northern Territory, Australia, meteorite. This specimen was polished, and previous etching showed that the structure was normal in every way. For comparison of results, the various reagents were applied in adjacent rectangles, and, when necessary, the specimen was repolished and re-etched. The figures could be faintly seen without etching, and breathing onto it, as suggested by Foote, did not improve their visibility even temporarily.

Reberholt's discovery was made by observing the improvement in etching near a label glued to a specimen. He recommends carpenter's glue, but, at the time, I was unaware of even the type of glue employed. Accordingly, I began by using LePage's mucilage, an animal glue somewhat like that used by carpenters. The resulting etch was lighter and brighter than the etch from the same solution without glue and considerably better in general. With a magnifier, it was seen that the result was light because the glue tended to supress the formation of etch-pits and general roughening. The Neumann lines also were developed more strongly.

Since glue is impure gelatine, I added a small quantity of gelatine

solution to the acid in place of the glue. The result was apparently the same.

Raw egg-white was partly precipitated by the acid, but the milky solution obtained gave a result better than did plain acid, but inferior to that given by acid plus glue.

Most labels use an adhesive based on gum arabic; therefore, I added a gum-arabic solution to the acid in place of the other constituents. This gave a result comparable to that of the egg-white.

Gum tragacanth thickened the reagent too much for practical use, but the etch was about equal to that obtained when glue was used.

Carboxymethyl cellulose "jells" in acid solution, but, nevertheless, the etch was again equal to that obtained with the glue solution.

Since phenol is used as a preservative in animal glues, some was dissolved in the acid solution. There was perhaps a slight improvement, but not much.

From these experiments, it seems that the effect of glue is not unique, but is shared in some degree by other colloids. The fact that glue is a protein does not seem to be important, nor does the phenol used as a preservative appear to be important.

Among other solutions tried were stannous and stannic chlorides and silver nitrate. These were without effect, even when weakly acidulated.

Mercuric chloride, in either water or aqueous alcoholic solution, slowly forms a dark gray coating of finely divided mercury. This coating is easily removed and the metal is found to be covered with etch pits. Prolonged etching gives very faint traces of Widmanstätten figures.

A 4% solution of aurichloric acid ($HAuCl_4$) rapidly attacked the metal, leaving a reddish-brown deposit of finely divided gold. This deposit rather easily rubs off, revealing dull, pitted kamacite and almost black taenite. This aurichloric acid, copper salts, and mercuric chloride gave the nearest things to different etch patterns of any reagents tried. The first two differed in the color of the figures they produced, and the last in the development of etch pits in preference to Widmanstätten figures; otherwise, the figures were of the usual size and shape.

Ammoniacal copper sulfate behaved similarly but gave a somewhat better etch. The copper adhered tightly to the taenite, but some of it could be rubbed off of the kamacite.

Bromine water is very unpleasant to work with, but readily gives ordinary figures appearing somewhat less brilliant than when nital is used; it colors troilite black, and tends to stain the iron, even in the absence of troilite. The stain is easily removed with dilute nitric acid, and the blackened troilite does not stain the adjacent iron. Unblackened troilite stains badly with plain acid, but not with nital.

A solution of iodine in potassium-iodide solution acts similarly.

Both hydrochloric and sulfuric acid in dilute solution will etch

meteoritic iron, but they are inferior in their results to nitric acid, the figures they produce appearing dull and lifeless.

Alcoholic picric acid hardly disturbs the polish of the metal, but does bring out the structure to some extent.

Perry[5] mentions the use of ammonium persulfate for the macroetching of meteorites. He mentions also several reagents for microetching.[6]

None of the reagents that I tried gave any new kinds of figures and none was superior to aqueous or alcoholic nitric acid except those containing colloids; of the latter, glue is the simplest to obtain and add, and is as good as, or better than, any of the others.

In addition, some experiments were made in which photographic printing paper was soaked in acid and pressed onto the surface of the meteorite for a time. Afterward, attempts were made to develop the structure of the meteorite on the paper by treatment with chemicals that give colored precipitates with iron or nickel or both. This procedure was suggested by the well-known technique of sulfur printing. The results were, however, uniformly disappointing, altho they did suggest that, with further work, such a technique might be successfullydeveloped. In this connection one is reminded of several early descriptions of meteorites, in which the structure was beautifully brought out by deep etching, after which the specimens themselves were inked and used directly for printing, like type or halftone plates; the result, tho reversed, was in some respects superior to modern photographs.

REFERENCES

[1] O. C. Farrington, *Meteorites*, p. 129, Chicago, 1915.

[2] M. H. Hey, *Nature*, **143**, 764, 1939; Guglielmo (or William) Thomson, *Atti Accad. Siena*, **9**, 37, 1808 (but dated Feb. 6, 1804); R. T. Gunther, *Nature*, **143**, 667-8, 1939.

[3] A. E. Foote, *Am. Jour. Sci.* (4), **37**, 391, 1914.

[4] B. O. Reberholt & E. P. Henderson, *Am. Mineralogist*, **34**, 606-8, 1949.

[5] S. H. Perry, "The Metallography of Meteoric Iron," *U. S. Nat. Mus. Bull. 184*, pp. 95-6, 1944.

[6] S. H. Perry, *op. cit.*, ref. (5), pp. 97-101.

The 14th Meeting of the Society, 1951 June 18-20

The 14th Meeting of the Society will be held at the University of Southern California, Los Angeles 7, California, 1951 June 18-20 (*v. C.M.S., P. A.*, **59**, 156, March, 1951).

Erratum in the April, 1951, Issue.—On p. 212, in the third-from-the-last line of the first paragraph of the paper by Frederick C. Leonard, "qualified" should read "qualifier."

President of the Society: L. F. BRADY, Museum of Northern Arizona, Flagstaff, Arizona

Secretary of the Society: JOHN A. RUSSELL, Department of Astronomy, University of Southern California, Los Angeles 7, California

The Planets in July and August, 1951

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. This period is the warmest season for most of the northern hemisphere, even though the earth will be farthest from the sun on July 4. From near maximum northern declination at the beginning, the sun will move steadily southward to less than 9 degrees north of the equator at the end of the period.

Moon. The phases of the moon will occur as followos:

New Moon	July	4	2 A.M.
First Quarter		11	11 P.M.
Full Moon		18	1 P.M.
Last Quarter		25	1 P.M.
New Moon	August	2	5 P.M.
First Quarter		10	6 A.M.
Full Moon		16	9 P.M.
Last Quarter		24	4 A.M.

The moon will be nearest to the earth on July 17 and August 14. An occultation of τ Scorpii, just east of Antares, will be visible from the western half of the country on August 11, beginning shortly after 10 P.M.

Evening and Morning Stars. Venus and Saturn will be visible in the early evening, Jupiter after midnight, and Mars at dawn.

Mercury. Mercury will reach more than 27 degrees east of the sun on August 3, and hence may be seen in the evening twilight within about ten days of that date.

Venus. Venus will climax a most favorable season of visibility by appearing at greatest brilliancy on July 29. After that, it will approach the sun with increasing rapidity so as to become invisible before the end of the period.

Mars. Slowly receding from the sun in the morning sky, Mars will be rising nearly two hours ahead of it by the end of this period. However, a comparative faintness of 2nd magnitude will greatly inhibit its conspicuousness.

Saturn. Although rapidly being overtaken by the sun, Saturn will still be up until nearly two hours after sunset, and will lose little in brilliancy.

Uranus. Uranus will pass conjunction with the sun on July 2, but it might be spotted just half a degree south of Mars on July 20.

Neptune. Neptune will be moving slowly southeastward at about half a degree south of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
May 5, 1951.

Asteroid Notes

By HUGH S. RICE

The brightest asteroids available for early-summer observing are as follows: (1) 85 Io, of magnitude 9.9, is at opposition to the sun July 11, and may be found in the southern part of Aquila. (2) 2 PALLAS, of magnitude 9.3, is at opposition July 20, and may be located mostly in the southeastern part of Sagitta, tho not crossing the arrow itself. (3) 19 FORTUNA, of magnitude 9.7, is at opposition July 23, and may be found in western Capricornus and eastern Sagittarius. (4) 8 FLORA, of magnitude 8.7, is at opposition July 31, and may be located in central and southwestern Capricornus. (5) 444 GYPTIS, of magnitude 10.1, is at opposition August 17, and may be found mostly in northern Aquarius.

As recorded by professional observers in Japan and Italy, Ceres, Pallas, Juno, and Vesta in 1950 were exceedingly close to their computed paths, none being usually over 0^m1 off in right ascension or 1′ in declination, and some of the Vesta positions as observed having residuals of 0^m0 and 0′0. Certain other planets, besides the "Big Four" above, also had zero residuals (observed minus computed values)—such as 136 Austria, 1036 Ganymed, 588 Achilles, and 10 Hygiea. Vesta is reported by some expert New York observers to have been considerably off the course as predicted, last November. We cannot understand this. The ephemeris as printed in this department is correct. And *Minor Planet Circular* 498 shows that Dr. Conti and Dr. Fortini at Monte Mario, Italy, got zero residuals; and our careful checking of their observed positions demonstrates that the planet was exactly on the predicted apparent path at the time of their observations.

ASTEROID EPHEMERIDES
0^h U.T. Equinox 1950

2 PALLAS

1951	α h m	δ ° ′	1951	α h m	δ ° ′
June 13	20 20.7	+19 4	July 18	19 58.3	+19 1
18	20 18.6	+19 20	23	19 54.2	+18 35
23	20 16.0	+19 32	28	19 50.2	+18 3
28	20 13.0	+19 38	Aug. 2	19 46.4	+17 25
July 3	20 9.7	+19 38	7	19 42.7	+16 42
8	20 6.1	+19 32	12	19 39.3	+15 54
13	20 2.2	+19 20	17	19 36.2	+15 1

85 Io

1951	α h m	δ ° ′	1951	α h m	δ ° ′
June 13	19 36.0	— 2 2	July 3	20 24.0	—16 45
23	19 31.0	— 1 8	13	20 15.8	—17 6
July 3	19 24.0	— 0 36	23	20 6.2	—17 33
13	19 15.9	— 0 29	Aug. 2	19 56.4	—18 2
23	19 7.8	— 0 47	12	19 47.5	—18 30
Aug. 2	19 0.9	— 1 30	22	19 40.6	—18 54

19 FORTUNA

8 FLORA

1951	α h m	δ ° ′	1951	α h m	δ ° ′
July 3	21 2.4	—18 18	July 23	21 59.6	+ 2 49
13	20 56.6	—19 20	Aug. 2	21 54.9	+ 2 27
23	20 48.2	—20 35	12	21 48.5	+ 1 40
Aug. 2	20 38.2	—21 53	22	21 41.3	+ 0 31
12	20 27.9	—23 5	Sept. 1	21 34.5	— 0 53
22	20 18.9	—24 2	11	21 29.1	— 2 24

444 GYPTIS

Hayden Planetarium, American Museum of Natural History, New York, 1951 May 19.

Occultation Predictions for July and August, 1951

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

				IMMERSION				EMERSION			
Date 1951	Star	Mag.	Greenwich C.T.	*a*	*b*	Angle E from N		Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°		h m	m	m	°
	OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′										
July 21	42 Aqar	5.6	4 2.9	−1.5	+0.8	111		4 47.0	−0.7	+2.3	188
24	62 Pisc	6.1	6 44.2	−1.7	+1.2	94		7 38.4	−0.2	+2.8	189
24	δ Pisc	4.6	7 9.9	−1.1	+1.9	54		8 25.7	−1.3	+1.7	228
30	406 B.Taur	5.6	7 34.8	+0.7	+1.9	49		8 24.4	−0.4	+0.8	292
Aug. 9	BD−19°3880	6.4	23 22.8	−2.3	−0.4	74		0 21.0	−1.2	−2.0	338
17	δ Capr	3.0	1 7.2	−0.9	+1.3	88		2 9.8	−1.1	+1.8	220
18	λ Aqar	3.8	8 57.3	−1.2	−0.8	79		9 55.4	−0.3	+0.7	210
22	20 H¹. Arie	6.4	9 31.2	−2.3	−0.3	89		10 43.0	−1.2	+2.0	208
24	16 Taur	5.4	5 41.6	..	..	132		6 7.9	..	..	180
24	*q* Taur	4.4	5 45.5	−0.6	+1.4	90		6 46.0	−0.2	+2.4	221
24	21 Taur	5.8	6 8.1	−0.7	+1.5	87		7 12.5	−0.4	+2.4	223
24	22 Taur	6.5	6 13.0	−0.9	+1.3	96		7 12.3	−0.2	+2.7	214
24	18 Taur	5.6	6 23.5	..	..	353		6 45.8	..	..	316
25	BD+26°731	6.5	6 6.6	−0.1	+1.8	68		7 12.0	−0.6	+1.7	255
	OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′										
July 24	62 Pisc	6.1	6 20.8	−0.6	+1.7	73		7 23.9	−0.5	+2.2	217
24	δ Pisc	4.6	6 52.2	−0.3	+2.2	32		7 56.6	−1.3	+1.6	255
Aug. 18	λ Aqar	3.8	8 33.9	−1.3	+0.5	55		9 44.5	−0.9	+0.4	227
22	20 H¹. Arie	6.4	8 51.4	−1.6	+1.5	65		10 13.1	−1.5	+1.8	225
24	16 Taur	5.4	5 27.0	−0.1	+1.0	104		6 13.7	+0.5	+2.2	212
24	*q* Taur	4.4	5 38.8	+0.2	+1.5	71		6 37.8	−0.1	+1.8	243
24	20 Taur	4.0	5 56.3	−0.4	+1.0	108		6 41.6	+0.5	+2.5	206
24	21 Taur	5.8	5 59.7	+0.1	+1.6	67		7 0.7	−0.3	+1.8	246
24	22 Taur	6.5	6 2.2	0.0	+1.5	75		7 2.7	−0.2	+1.9	238
25	BD+26°731	6.5	6 6.9	+0.6	+1.8	49		7 0.0	−0.3	+1.2	277
	OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +31° 0′										
July 24	62 Pisc	6.1	6 3.6	−0.4	+1.3	81		7 0.9	−0.3	+2.3	211
24	δ Pisc	4.6	6 30.7	−0.2	+2.1	38		7 34.0	−1.0	+1.6	251
29	38 B.Auri	6.5	10 35.2	−0.5	+1.4	77		11 47.4	−1.0	+1.8	248
Aug. 12	τ Scor	2.9	5 7.0	−1.6	−1.6	115		.. ....	..	..	....
18	λ Aqar	3.8	8 17.3	−1.9	+0.7	63		9 30.6	−0.9	+1.3	213
22	20 H¹. Arie	6.4	8 26.0	−1.7	+1.5	70		9 43.7	−1.2	+2.5	213
	OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′										
July 15	4 Scor	5.6	5 14.4	−2.4	+0.3	63		6 14.4	−1.9	−2.0	326
21	σ Aqar	4.9	11 54.4	−3.2	−1.7	107		12 34.6	+0.6	+3.0	174
29	38 B.Auri	6.5	10 49.2	+0.9	+2.5	28		11 31.4	−1.0	+0.3	300
Aug. 12	τ Scor	2.9	4 21.6	−2.1	−0.5	92		5 41.6	−1.7	−1.1	280
18	λ Aqar	3.8	7 58.9	−0.4	+2.6	5		8 54.1	−2.8	−0.1	274
22	20 H¹. Arie	6.4	8 21.4	+0.1	+2.6	20		9 18.5	−1.7	+1.1	270
23	ε Arie	4.6	7 58.2	−0.5	+1.2	92		8 53.3	+0.1	+2.5	209

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In these notes will be given the results, so far as they have reached me, of all the observations in 1951 by P. Burt and C. E. Worley, those of A. Pearlmutter from April 6 to May 8 (but only a résumé of his observations for May are here, without his maps), those of R. M. Dole from April 20 to May 6, and those sent by Miss J. R. Gill of Smith College Observatory for May 4. A class of 13 students took part; the meteors were not plotted but each was described. No duplicates were included. Eight students observed at once, facing in different directions, the others recording. It is sincerely hoped that more reports, especially on the very important Eta Aquarids, will arrive shortly, but it seemed wise to give without delay such results as we have both on them and the Lyrids.

We find good radiants for the Lyrids on the maps of Dole and Pearlmutter. Dole's radiants, A.M.S. Nos. 3169 and 3170, differ so little in position that, despite their sharpness on the map, the little difference is probably within observational error. Pearmutter's radiant No. 3162 is based upon 2 meteors on April 16, 4 on April 17, and is far enough from No. 3165 to indicate motion during the 3-day interval. His radiants Nos. 3163 and 3164, when combined together, give No. 3165. On his maps, of which he used three that night, *i.e.*, April 20, two centers about 7° apart are shown. One has the choice of considering the Lyrid radiants as an oval about 7° x 3° in area, of it being double and each rather sharp, or that it is single and ordinary errors of observation make it look rather large, and the single true radiant is No. 3165. The one remarkable thing about his observations on this night is that he recorded 86 meteors, some of them very faint, in 4½ hours, despite the Moon being about full. He also gives F = 0.9. This last is not in accord with our custom for we never give F greater than 0.4 or 0.5 with so much moonlight present. The rate in the last column for that night is therefore unexpectedly high, which must have meant that the air was unusually clear in his locality on that night and his eyes in excellent condition. Incidentally, he has been doing very good work during both 1950 and 1951 and is turning out to be one of our most faithful observers.

Coming to the Eta Aquarids, we have Dole's radiants Nos. 3148, 3149, and 3150; Worley's Nos. 3158 and 3159. Pearlmutter's maps are not yet here. Again, Dole's three positions are so close together that I hardly venture to say that motion is shown from day to day. Worley's two radiants do indicate motion and, so far as that in right ascension is concerned, in the right direction. What both observers saw indicates that the Eta Aquarids returned in average intensity. It is to be remembered that the parent comet, Halley, is now quite near aphelion. Better rates may well be expectd as 1985 approaches. Radiant No. 3147 by Dole, though sharply based upon 13 meteors, is difficult to understand, assuming that he not only plotted the directions but also the lengths of the paths correctly on his map. It is almost at the star Epsilon Pegasi, but of the 13 conforming meteors all but 2 have paths from 15° to 20° long, and 7 seem to start within a degree or two of the radiant itself. In other words only 4 of the 13 start far enough from the derived radiant for their plotted paths to be of the usually expected lengths for their relative positions. He further reports that 8 of them were seen within 6 minutes, then later that 5 more were seen within the last 3 minutes of observation. They were all very swift. That it must have been a purely local phenomenon is proved by the fact that Worley, on the same night, did not see a single meteor whose path would have projected to anywhere near Epsilon Pegasi.

As the summer months, with warm nights, is now approaching, and also the holiday season for many of our members who have been kept busy in school or college, we hope to have a great increase in observing. Is it too much to ask that our numerous inactive members will, at least occasionally, put in a few hours of work on meteors? The two main summer showers, the Delta Aquarids and the Perseids, maximum between July 26 and 31 and August 10 and 13, respectively, will not be troubled by moonlight. The Moon will be new on August 2 and at first quarter on August 10; so conditions could hardly be better. However, persons need not wait for the dates mentioned to do good work, as on any clear, moonless night from about July 15 to December 15 a fair hourly rate may be expected, larger of course after midnight. We have full supplies of maps and record sheets on hand, but as the writer will be away from home much of the summer, early requests for essential needs would be appreciated.

The two tables contain as usual the necessary information about the rates of meteors observed during the intervals mentioned and for the nights on which radiants may have been derived. The table of radiants is arranged as usual. In the last column a few numbers, standing without explanation, refer to former A.M.S. radiants which are considered to verify these new radiants. However, it is a very slow and tedious task to make anything like a serious search for such verifications and what has been done in this case is most incomplete. No doubt many of the others could be verified by a more thorough search of our radiant card-file.

The last item in these Notes is the discussion of a fireball, which unfortunately could not be fully computed, for reasons which will appear.

TABLE I

Observer and Station	Date 1951		Began	Ended	Min.	Met.	F	Unc. Rate
Dole, R. M., Cape Elizabeth, Maine	Apr.	20	10:30	12:30	120	12	0.3	6
"		21	10:30	12:30	120	9	0.4	4
"	May	3	14:15	15:15	60	12	1.0	12
"		4	14:15	15:15	60	39	1.0	39
"		6	14:30	15:15	45	9	0.7	12
"		8	14:15	15:15	60	5	0.5	5
Smith College Observatory, Northhampton, Mass.								
Gill, Miss J. R. and 13 students	May	4	11:02	13:00	118	33	0.7	..
Worley, C. E., St. Louis, Mo.	Feb.	10	12:10	15:10	180	23	0.7	8
Worley, C. E., St. Louis, Mo.		11	13:00	13:45	45	7	0.8	9
Worley, C. E., Ottumwa, Iowa	Apr.	3	11:00	15:00	195	30	1.0	9
Worley, C. E., St. Louis, Mo.		13	10:30	11:10	40	4	0.7	6
Worley, C. E., St. Louis, Mo.	May	3	14.05	15:50	105	23	1.0	13
Worley, C. E., Pacific, Mo.		4	14.05	15:50	105	31	1.0	18
Pearlmutter, A., Forest Hills, L. I., N. Y.	Apr.	6	8:45	12:00	195	25	0.9	8
"		7	8:13	12:00	227	22	0.9	6
"		16	9:14	10:15	61	10	0.9	10
"		17	9:31	10:31	60	11	0.7	11
"		18	8:52	9:30	38	6	0.6	10
"		19	8:40	11:09	..	..	0.5	..
"		20	9:30	14:00	270	86	...	19
"		23	9:20	11:20	180	25	...	8
"		30	13:51	15:15	81	13	0.9	10
"	May	1	13:54	15:30	96	22	...	14
"		2	13:58	15:30	92	26	...	17
"		3	14:20	15:45	85	26	...	18
"		4	13:50	16:00	130	41	...	19

Observer and Station	Date 1951	Began	Ended	Min.	Met.	F	Unc. Rate
Pearlmutter, A., Forest Hills, L. I., N. Y.	May 5	13:28	16:00	152	51	...	20
"	8	14:25	15:40	75	21	...	17
Burt, P., Memphis, Tenn.	Mar. 30	11:30	14:00	125	24	1.0	12
"	31	10:00	11:15	75	10	1.0	8
"	Apr. 13	13:00	14:00	60	6	1.0	6
"	14	14:00	15:30	90	9	0.8	6

TABLE II

A.M.S. No.	Date 1951 G.M.T.	R.A.	Decl.	Meteor	Acc.	Notes
3147	May 4.82	325°	+ 9°	13	?	
3148	May 3.82	338.1	— 1	10	G	Eta Aquarids
3149	May 4.82	337.9	— 1.5	7	G	Eta Aquarids
3150	May 6.83	338	+ 0.5	6	G	Eta Aquarids
3151	Feb. 11.81	163	+10	4	G	
3152	Feb. 10.86	180	+ 2	7	G	
3153	Apr. 3.79	222.5	+ 5	8	G	
3154	Apr. 3.79	274	+10	3		
3155	May 4.79	274	+ 8	4	FG	
3156	May 3.89	297.5	— 5	3	F	3157
3157	May 4.89	299	— 4	4	G	3156
3158	May 3.89	331.7	— 5.7	6	G	Eta Aquarids
3159	May 4.89	334.4	— 3.6	7	G	Eta Aquarids
3160	Apr. 6.5	213	+24	4	FG	
3161	Apr. 6.5	239	—21	3	F	
3162	Apr. 17.3	273	+36.5	6	G	Lyrids
3163	Apr. 20.67	275	+38	16—	G	Lyrids
3164	Apr. 20.67	282	+36.5	14—	G	Lyrids
3165	Apr. 20.67	277	+37.5	28	G	Lyrids
3166	Apr. 20.67	327	— 5	4-6	FG	
3167	Apr. 20.67	342	— 7.5	4-7	FG	
3168	Apr. 14.85	258	+28	4	FG	100!
3169	Apr. 20.69	282.4	+37.2	9	G	Lyrids
3170	Apr. 21.69	280.9	+37.0	5	G	Lyrids
3171	Mar. 31.1	247	+63	9	P	very diffuse
3172	Mar. 31.69	220	+68	4	FG	945

Radiants Nos. 3168, 3171, 3172 by P. Burt.
Radiants Nos. 3147-3150, 3169, 3179 by R. M. Dole.
Radiants Nos. 3151-3159 by C. E. Worley.
Radiants Nos. 3160-3167 by A. Pearlmutter.

Fireball of 1948 November 29/30; A.M.S. No. 3550

On this date at 7:34.5 ± 1.5 P.M., E.S.T., a fine fireball appeared at or near the zenith of Green Island, N. Y., and fell in the direction (from there) between west and southwest. Dr. Robert Fleischer, Department of Physics, Rensselaer Polytechnic Institute, Troy, N. Y., hearing of its appearance put a note in the local papers asking for reports. Thanks to this, three persons reported; I also received reports from three other localities.

It was hoped that a solution could be made, and one has been attempted. But I regret to say that only one of the six reports is approximately complete. This was made by Miss Barbara Sabin, a student at Smith College, Northampton, Mass. (S1). Two others, Mr. and Mrs. H. Goodwin at Green Island, N. Y. (S2), and Mrs. R. H. Andrews of North Troy, N. Y. (S4) state that it started directly above them. These places being very near, we can combine them with the beginning altitude of 40° ± at S1 and deduce an approximate beginning height at 81 km. The sidereal time at S1 was 2°.

From the data at S1, I calculate that the fireball disappeared below the horizon, obstructed by trees and buildings, in azimuth 84°. However, no one else gives the azimuth of the end point with any approach to exactness, hence neither the end height can be calculated nor the sub-end point through the fireball ended well above the horizon at Troy and vicinity. This precludes calculation of the path, radiant, etc. As S1 gives the angle with the horizon as 48°, the object going towards the S.W., projecting the path on the globe shows it cannot be a late Bielid.

All agree the fireball moved slowly: two give 30 seconds as duration, one 3 to 4 seconds. The given colors were: blue, blue-white, and orange—the last from (S5), Newburgh, the most distant station. All agree that it was a very bright object.

While I am quite aware that little of value is found in the above discussion, still perhaps even this much should be placed on record. It may be added that, once such a result is printed, all reports and calculations bearing on the object are filed in a special envelope so that, should more data ever turn up, they could be combined with the older and a revised solution made.

Flower Observatory of the University of Pennsylvania, Upper Darby, Pa.
1951 May 26.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By MARGARET W. MAYALL, Recorder

The 1951 Spring Meeting of the AAVSO was held in Washington, D. C., on May 11-13. The meeting was greatly saddened by the passing of our beloved Honorary Recorder, Leon Campbell, on May 10, but it was decided that, in tribute to his spirit, all plans should be carried out as arranged.

Through the kindness of the Rev. Francis J. Heyden, S.J., Director of the Georgetown University Observatory, all the sessions were held in the Copley lounge at Georgetown University.

Dr. John S. Hall, of the U. S. Naval Observatory, gave a lecture Friday evening on "The Effects of Scintillation of Stars." He illustrated his talk with some motion pictures taken with a perforated diaphragm mounted on the end of the 40-inch telescope.

AAVSO members and their guests were privileged to visit two large observatories. Father Heyden had open house at the Georgetown University Observatory after Dr. Hall's lecture; and on Saturday evening Mr. Morgan Cilley arranged a very complete tour of the United States Naval Observatory. Mr. Arthur Hoag demonstrated the effects of scintillation on a bright star with the famous 40-inch telescope. Clear skies favored us with good observing.

At the business session on Saturday morning it was announced that Mr. Richard W. Hamilton had been appointed to act as Variable Commentator for the meeting. The Nominating Committee proposed the following slate for Council Members, to be voted on at the fall meeting: James C. Bartlett, Jr., Thomas A. Cragg, Jocelyn Gill, Donald S. Kimball, and Emil A. Sill. One new life member and 25 new annual members were elected.

LIFE MEMBER

Mrs. Cyrus F. Fernald, Wilton, Maine

ANNUAL MEMBERS

Hugh G. Boutell, Santa Barbara, California; Michael J. Bozich, Pittsburgh, Pennsylvania; Joseph M. Chamberlain, Kings Point, New York; Dale R. Congdon, Hopkins, Minnesota; Gunnar O. Darsenius, Gothenburg 1, Sweden; Rene J. L. H. Ficonetti, Ollioules, France; Y. William Fisher, Brussels 3, Belgium; Philip D. Gray, Flushing, New York; David Halvorson, Minneapolis, Minnesota; Edward Huss Jones, Washington 7, D. C.; Arvid W. Lindblad, West Boylston, Massachusetts; Russell C. Maag, Fulton, Missouri; Allen C. Montague, Oak Park, Illinois; Arthur G. F. Morrisby, Capetown, South Africa; John Ward Mount, Long Branch, New Jersey; J. G. Moyen, Los Angeles 19, California; Michael Robins, Chicago 40, Illinois; Harold A. Sanders, Jr., Heppner, Oregon; Giuseppe Santandrea, Rio de Janeiro, Brazil; Axel Schmuhl, Copenhagen, Denmark; Charles E. Tarwater, Long Beach 3, California; Olier D. Valliere, Jamaica Plains, Massachusetts; Stanley L. Whitehill, Baltimore 1, Maryland; Sydney Makepiece Wood, Groveland, Florida; Roderick V. Woodbury, Neponset 22, Massachusetts.

An excellent group of papers was presented at the meeting: 1) Miss J. Virginia Lincoln, National Bureau of Standards, On a New Method of Determining American Sunspot Numbers; 2) John Lankford, A New Theory of Novae; 3) Alika Herring, Declaration of a Proposed Research; 4) Margaret W. Mayall, Remarks on Some Variables; 5) Martin McCarthy, S.J., Georgetown Observatory, Colors of Cepheids; 6) Dr. Gleissberg and Dr. Dizer, Istanbul, Turkey, Evidence of an Apparent Relation between the Formation of Different Sunspot Groups; and 8) John W. Streeter, Observations of Neptune.

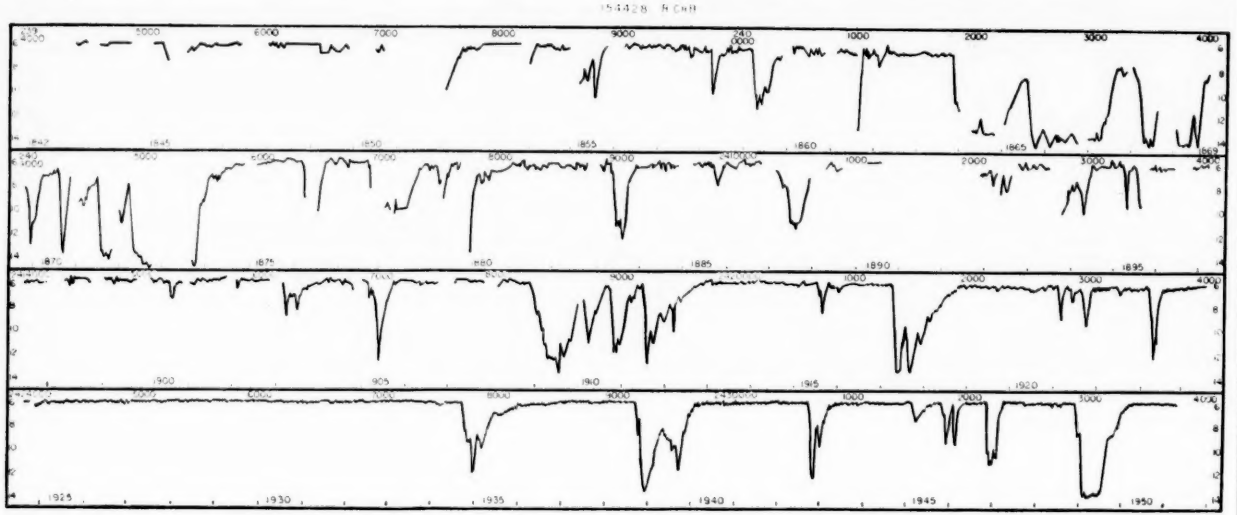
The recorder had on exhibit two light curves of more than one hundred years of observations each, of R Scuti and R Coronae Borealis (see page 334). These were a tribute to the painstaking work of Mr. Campbell, who collected and plotted all the early visual observations of these two variables. Also on exhibit were light curves of Nova Lacertae 1950 (DK Lac); 001755 T Cas, a variable with a 445 day period, and a well-marked hump, or stillstand, on the increasing branch of the curve; and 020448 RV And, a star listed as semi-regular with a period of about 167 days, but which appears to be similar to Z UMa. The photographic light curve of 195656 RR Telescopii from 1890 to 1948 was shown, with visual observations from 1948 through 1951. This is the star that varied from 12 to 14 photographic magnitude until 1945, when it suddenly increased to about 7th magnitude, and has gradually faded until now it is about 9th magnitude.

Sunday was a day for inspecting radar equipment. In the morning, a trip was made to the Sterling Field Station of the National Bureau of Standards. In the absence of Mr. Alan H. Shapley, the group was guided by Miss Virginia Lincoln, who explained and demonstrated the three large antennae used for the study of solar noise. In the afternoon, Dr. John P. Hagen gave a demonstration of the work being done at the Naval Research Laboratory on solar and stellar noise.

An invitation was accepted from Dr. Harlow Shapley, to hold the annual fall meeting of the AAVSO at the Harvard Observatory some time in October.

CORRECTION

In these notes for May (*P. A.*, **59**, p. 274, 1951) the variable discovered by Robert Greenley was incorrectly identified as Zinner 402. Mr. Greenley's variable



LIGHT CURVE OF R CORONAE BOREALIS FROM 1843 TO 1951

All early observations collected and plotted by Leon Campbell. Observations before 1900 by Argelander, Baxendell, Schmidt, Schoenfeld, Winnecke, Kuhn, Auwers, Groth, Hartwig, Schwab, Safarik, Sawyer, Wilsing, Parkhurst, Eadie, Markwick, Pickering, Wendell, and others. From 1911 to 1951, observations by the AAVSO.

is $0^m.4$ east and 5′ north of the 8.4 comparison star of S Camelopardalis. Its approximate 1900 position is $5^h\ 35^m$, $+68°\ 50'$, and it is probably a new variable. The observed range is from 9.5 to 10.8 magnitude.

Observations received during April, 1951: A total of 4,866 observations was received during the month from the following 66 observers:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Adams, R. M.	45	130	Lacchini, G. B.	9	9
Ahnert, P.	30	194	Leutenegger, E.	22	69
Ancarani, M.	14	26	LeVaux, H. A.	106	106
Armfield, L. E.	3	3	Mary, D.	8	8
Born, E.	24	254	Meek, J. W.	32	178
Buckstaff, R. N.	10	11	Melville, E. C.	11	15
Cain, C. V.	1	2	Mielke, H.	16	69
Chandra, R. G.	73	93	Miller, W. A.	32	52
Charles, D. F.	10	12	Morrisby, A. G. F.	8	36
Cobb, H.	3	5	Motley, G.	29	46
Costello, R. B.	9	9	Oravec, E. G.	71	182
Cragg, T.	122	124	O'Sullivan, W.	21	49
Darling, B.	20	44	Parker, P. O.	40	40
Darnell, P.	1	4	Pearcy, R. E.	5	5
Darsenius, G.	7	21	Peltier, L. C.	38	129
Diedrich, DeL.	2	4	Penhallow, W.	5	5
Diedrich, G.	4	10	Peter, H.	39	259
Domke, K.	27	229	Pohl, E.	17	119
Escalante, F. J.	96	143	Renner, C. J.	111	111
Estremadoyro, V. A.	10	13	Rick, L.	1	1
Fernald, C. F.	143	205	Rosebrugh, D. W.	20	93
Fernald, E. S.	2	2	Schulte, D.	13	13
Ford, C. B.	14	14	Segers, C.	22	139
Galbraith, W. H.	39	111	Sill, E. A.	17	17
Garneau, DeL.	11	11	Snow, D.	4	4
Greenley, R. M.	69	155	Sofronijewitsch, D.	24	185
Hartmann, F.	130	130	Taboada, D.	103	104
Hiett, L.	19	38	Tarwater, C.	35	101
Howarth, M.	20	20	Venter, S. C.	22	26
Jerabek, H. S.	5	8	Weber, J. A.	23	23
Kato, H.	24	34	Wells, K. A.	2	2
Kelly, F. J.	12	12	Whitehill, S. L.	3	3
Knowles, J.	14	17	66 Totals		4,866
de Kock, R. P.	109	580			

Nova Search. Nova Search reports were received during April from 16 observers, as follows:

Observer	Area	Nights	Mag.	Observer	Area	Nights	Mag.
Adams, R. M.	33, 34, 53, 54, 65, 66	3	8		56	3	6
	33, 34	1	6		56	2	5
	53, 54, 71, 72	2	6	**Milton, E.	46	1	6
	65, 66	3	6	**Morgan, F.	34	10	6
	71, 72	4	8	**Noseworthy, T.	82	9	6
**Birtles, B.	81	3	6	*Rick, L.	Dome	7	1
**Cockhill, B.	51	3	6		18, 65	7	4
**DeKinder, F.	36	11	8	Rosebrugh, D. W.	Dome	8	3
*Diedrich, DeL.	94	3	5		1	1	4
	94	1	4		14	8	4
*Diedrich, G.	Dome	4	2	Smith, F. W.	3, 4	4	6
	Dome	1	1	Wells, K. A.	33-37, 49-54,		

Observer	Area	Nights	Mag.	Observer	Area	Nights	Mag.
	67-72, 80-84, 91-92	1	4.5	**Zackon, B.	92	1	6
**Williamson, I. K.	38, 79	9	6	**Zorgo, Mrs. K.	19, 110	4	6

*Member of the Black River Astronomical Society.

**Member of the Montreal Center of the Royal Astronomical Society of Canada.

May 18, 1951.

Evidence of an Apparent Relationship Between the Formation of Different Sunspot Groups*

By W. Gleissberg

The aim of the present paper is to draw attention to an interesting investigation which, at my suggestion, has recently been made by Dr. Muammer Dizer at Kandilli Observatory, near Istanbul. This investigation, which has not yet been published, deals with the following question: When several new-formed sunspot groups appear on the same day, is there a relation between their formation?

In order to answer this question Dr. Dizer made use of the Summaries of Mount Wilson Magnetic Observations of Sunspots as published bi-monthly in the *Publications of the Astronomical Society of the Pacific*. In these summaries it is stated on which day each sunspot group was first observed. For each group which has not come, already formed, around the limb, this day can be considered as its birthday provided that the sun has been observed also on the preceding day. During the period 1934-1944 solar observations were made at Mount Wilson Observatory on 3,513 days. But, for the reason stated, those of these days which followed a day without observation, had to be omitted from the statistics. Thus, only 3,284 days were taken into consideration. On these days 1,897 groups were formed. If one supposes that the birth-days of 1,897 groups are distributed at random over 3,284 days, the calculus of probability yields the result that on 1,843 days no group should be born, on 1,066 days one group should be born, and on 375 days more than one group should be born. But, according to the Mount Wilson Observations, there were 1,982 days with no new-formed group, 869 days with one new-formed group, and 433 days with more than one new-formed group. Thus during the period 1934-1944 the actually observed number of common birth-days of two and more sunspot groups, *viz.*, 433, was considerably greater than the number which was to be expected from the supposition of random distribution, *viz.*, 375. It is, therefore, evident that, whenever several new-formed groups appear on the sun's disk on one day, these groups must be related with one another, presumably by an apparent common impulse causing their formation.

A similar result was obtained for spot groups disintegrating on one day.

University Observatory, Bayazyt, Istanbul, Turkey.

*Read by Mr. Neal J. Heines, President of the AAVSO and Director of the AAVSO Solar Division, at the Spring Meeting, 1951, of the AAVSO held at Georgetown University, Washington, D. C., on May 12, 1951.

Comet Notes

By G. VAN BIESBROECK

Since last month there have been three additions to the list of comets found this year.

COMET 1951 *e*. The first is the expected periodic comet KOPFF which was recovered by H. M. Jeffers at the Lick Observatory according to the following announcement:

1951 April 12.39833 UT $12^h\,11^m\,30^s.3$ $-12°\,52'\,36''$
Magnitude 18. Diffuse. No tail reported.

The same night Bester and Johnson at Bloemfontein (South Africa) independently recorded an object of magnitude 15 as being the comet but their position differs much more from the ephemeris and was not corroborated by later measures. The correction of the ephemeris by Beart and Julian (*Handb. B.A.A.*, 1951, p. 44) is only $+0^m.7$ and $-3'$ from Jeffers' observation and this shows that perihelion will occur about half a day earlier than their prediction of October 20.551. The comet is, however, considerably fainter than expected and this is confirmed by plates taken here May 3 and 5 showing the object hardly as bright as magnitude 17 while the prediction for that time is 13.9. Fortunately the object is well situated in Virgo and it will be possible to follow it for some time in the evening sky as it brightens up; it will, however, remain only in reach of larger telescopes.

COMET 1951 *f*. This apparently new object was announced April 24 by L. Kresak. It was discovered in the course of the systematic search carried out at the Skalnate Pleso mountain observatory in Czechoslovakia, a search that had also located comet 1951 *a* last February. The first announcement gave only a rough position:

April 24 at $20^h\,54^m$ UT $8^h\,40^m.0$ $+30°\,30'$ Magnitude 10
Diffuse without condensation.

Being conveniently situated in Cancer the new object was measured by various observers the following days and this enabled the Berkeley computers, J. Brady and Miss N. Sherman, to secure a first determination of the orbit. The path of the comet proved to be elliptical:

Perihelion date 1951 May 9.282 U.T.	
Node to perihelion	38°4′
Longitude of Node	164 7
Inclination	14 26
Eccentricity	0.7288
Mean motion	416″.8,

corresponding to a period of 8.5 years. Figure 1 herewith represents the appearance of the comet from a 20-minute exposure with the 24-inch reflector here on May 8. The brightness had not changed appreciably since the first announcement and hovered around magnitude 11 on the Harvard Scale. The coma had a diameter of some 6′ and was well condensed centrally but no stellar nucleus was visible. The coma stretched away from the nucleus mostly in the position-angle 225° suggesting a broad diffuse tail in that direction.

This latest addition to the list of periodic comets will be favorably located

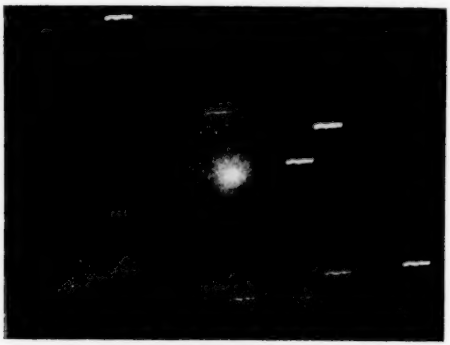


FIGURE 1
COMET 1951 *f* (KRESAK)

for some time but it is slowly losing in brightness. In June it will cross the constellation of Coma Berenices as seen from this short ephemeris:

	α	δ
	h m	° ′
May 24	11 3.2	+34 18
June 3	11 59.1	32 7
June 13	12 51.8	+28 12

the magnitude being expected to vary from 11 to 12 in that interval.

COMET 1951 *g*. The expected periodic comet NEUJMIN (3) 1929 III has just been recovered by L. E. Cunning using the 60-inch reflector of the Mt. Wilson Observatory:

1951 May 4.473 U.T.: $21^h 29^m.2$ $-11° 53'$ Magnitude 17

This position is very nearly represented by Julian's ephemeris (*Handb. B.A.A.*, 1951, p. 40) with a perihelion date 1.5 days earlier than the computed value May 28.372. The comet was last seen in 1929 and had been missed at its return of 1940. It is a morning object but moves towards the middle of the night. It will gain somewhat in brightness this summer and be favorably located then but will remain as faint as magnitude 15. It is fortunate that this comet was recovered after 22 years.

Of the comets that were previously under observation 1950 *c* (MINKOWSKI) is the brightest. On May 3 I estimated its total intensity as 10.5 which is a little below the predicted value of 9.7. It will soon be lost in the evening sky but this distant object will presumably come again within reach in the fall.

The other comets are in reach of large telescopes only.

Williams Bay, Wisconsin, May 11, 1951.

General Notes

Dr. Ira S. Bowen, Director of the Mount Wilson and Palomar Observatories, gave the Friday Evening Demonstration Lecture on May 25, 1951, at the California Institute of Technology, Pasadena, on "The 200-inch Hale Telescope." The lecture was illustrated with lantern slides.

Dr. Otto Struve, Professor of Astronomy and Director of the Students' Observatory, University of California, Berkeley, lectured on May 17, 1951, under the auspices of the local Sigma Xi chapter, at the University of California, Los Angeles, on the subject of "Stellar Evolution."

Mr. Leon Campbell, an observer and recorder at the Harvard College Observatory, for more than 50 years, died on May 10 at Mt. Auburn Hospital, Cambridge, Mass., following a long illness. He was 70 years of age. Mr. Campbell, a member of the Observatory staff since 1899 had been Pickering Memorial Astronomer and Instructor in Astronomy at Harvard. We hope to have a suitable biographical account in the next issue of this journal.

Dr. Ralph E. Wilson, a member of the staff of the Mount Wilson and Palomar Observatories, operated jointly by the California Institute of Technology and the Carnegie Institution of Washington, retired on May 1 after a long and distinguished scientific career. His associates honored him at an informal reception in the Observatories Library on that day. A scientific symposium in his honor will be held in Pasadena on June 20 as one session of the summer meeting of the Astronomical Society of the Pacific, of which he was president in 1946. Its subject will be "Radial Velocity Programs of Pacific Coast Observatories."

He has spent most of his career in research on the motions of the stars and has achieved world-wide recognition as an authority on the subject. He took a leading part in preparing the monumental "Boss General Catalogue," which records the angular motions of more than 33,000 stars and recently completed a compilation of all known velocities of the stars measured with the spectroscope. He has been associated with the Mount Wilson Observatory since 1938, when he moved to Pasadena from Albany, N. Y., where he had served for two decades in the Department of Meridian Astronomy of the Carnegie Institution. During World War II he was a consultant to the Office of Scientific Research and development. During World War I he was the American representative on the Committee of Allies at Santiago, Chile, and also performed technical work for the Bureau of Aircfaft Production in Dayton, Ohio.

He was born in Cincinnati, Ohio, in 1886, and studied at Carleton College, Northfield, Minnesota, where his father, Herbert C. Wilson, was Professor of Astronomy, Director of the Goodsell Observatory, and Editor of POPULAR ASTRONOMY. After received his Ph.D. degree in astronomy from the University of Virginia in 1910, he became Acting Director of the Goodsell Observatory for one year during his father's absence. In 1911 he became an assistant in the Lick Observatory of the University of California and two years later went to Santiago as astronomer in charge of a Lick expedition to obtain spectroscopic observations of stars in the southern sky. He joined the Albany staff of the Carnegie Institution in 1918.

Dr. Wilson received the gold medal of the Danish Academy of Sciences in 1926 in recognition of the merit of his astronomical work. He is a member of the American Astronomical Society, the Astronomical Society of the Pacific, Sigma Xi, Phi Beta Kappa, the National Academy of Sciences, and the American Association for the Advancement of Science.

Dr. Wilson plans to make his future home in Corona del Mar.

(News release from California Institute of Technology.)

The Rittenhouse Astronomical Society of Philadelphia held its final indoor meeting of the season in the Little Theatre of the Franklin Institute on Friday, May 18. At that meeting Dr. William Blitzstein delivered a lecture on the subject "The Electric Eye Scans the Sky."

Contributions of the Astronomische Gesellschaft is the title of a pamphlet of 64 pages recently received. It covers the activities of this well-known Society for the year 1950. It contains an account of the fourth meeting of the Society, since the war, held September 8-11, 1950. The opening address by the president, Professor F. Becker, is given. This is followed by abstracts of 28 scientific papers that were presented. After that are given the annual reports of German Observatories, 15 in number. The last two pages are devoted to book reviews.

It is gratifying to note the renewed activity in this science in Germany and the revitalization of this historic society.

Provisional Sunspot Numbers for April, 1951*

1	41	11	84	21	149
2	27	12	88	22	144
3	24	13	78	23	140
4	20	14	103	24	119
5	40	15	118	25	115
6	61	16	126	26	114
7	69	17	130	27	114
8	78	18	148	28	98
9	75	19	150	29	81
10	74	20	132	30	65

Mean Value for April
R = 93.5

*From the Zürich Observatory, furnished by Mr. Neal J. Heines.

A Conference on Auroral Physics

A Conference on Auroral Physics, jointly sponsored by the Physics Department of the University of Western Ontario and the Geophysical Research Directorate of the Air Force Cambridge Research Laboratories, Cambridge, Massachusetts, will be held July 23 to 26 at the University of Western Ontario at London, Ontario.

The entire field on auroral physics will be given consideration, with important theoretical papers to be presented by internationally known scientists. General topics to be discussed will deal with the formation of the aurora, mechanisms of solar corpuscular streams and excitation mechanisms in the ionosphere (80-400 km) and in the mesosphere (400-1000 km).

Several papers will be presented on the identification and interpretation of the emission spectra of the ionosphere and mesophere and other observational studies.

The Cleveland Astronomical Society

Dr. Helen Sawyer Hogg of the David Dunlap Observatory of the University of Toronto addressed the April 27th meeting of the Cleveland Astronomical Society. Her subject was "Beacons of the Milky Way."

Dr. Hogg's beacons are the globular clusters upon which she has done a great deal of excellent work. Her lecture was well illustrated with slides dis-

tinguished between the galactic or open clusters which are distributed mostly near the principal plane of the Milky Way and the globular clusters which are more regular in form and have a greater central concentration of stars.

Some 1400 variable stars have been found in the 101 globular clusters. Most of these are short-period Cepheids having periods around half a day. They are very useful in determining the distances of the clusters in which they occur. The nearest globular clusters are about 20,000 light years away and the farthest, which Dr. Hogg referred to as an intergalactic tramp, is about 170,000 light years.

It was through a study of the distribution of these globular clusters or beacons that Dr. Shapley came to the conclusion that they are assembled in a vast spheroidal volume of space outlining the limits of our Milky Way system with center some 30,000 light years from our sun in the direction of the great star cloud in Sagittarius.

This interesting lecture was followed by a short question period.

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When Does a Century Begin?

The question in the title above suggests a point that is often discussed. The reasoning involved in such discussions is not particularly profound, but the question is of very general interest. Very likely it will never be known just how the reckoning was done at the beginning of the Christian era. The paper which follows puts the situation clearly before the reader. It is a paper by Dr. F. Heiland, published in "Die Sterne," Volume 27 (1951) page 1, translated from the German by Alma M. Hammer, of the Department of German, Carleton College. ED.

At the beginning of the year 1950 the question was frequently discussed whether the beginning of the second half of the current century should be set on January 1, 1950 or on January 1, 1951. The same problem, referring at that time to the beginning of the century, was discussed in 1900. Its solution came about by a higher order according to which the beginning of the 20th century was set on January 1, 1900. It is questionable, however, whether that was the right solution. We count the years, as is known, from the time of Christ's birth. Whether this calculation is correct, that is, whether the time with which we begin counting has been correctly determined, is of no importance. Significant for our problem is solely the observation that the years are counted from a certain date. As the starting point in our counting we customarily designate it as 0. With that the first year begins, thereupon follows the second, the third, etc. When the 100th year has ended, *i.e.*, on December 31, 100, the first century has come to a close, consequently, the second century begins on January 1, 101. Hence, the beginning of the 20th century is to be set on the first of January, 1901, and the beginning of its second half on January 1, 1951. Analogously, we count the years backwards from zero. Since, however, the months and days are counted in the same direction as in the time after Christ's birth, the beginning of the first pre-Christian century must be set on January 1, 100 B.C.

3 yr. B.C.|2 yr. B.C.|1 yr. B.C.|Birth of Christ|1 yr. A.D.|2 yr. A.D.|3 yr. A.D.

In this manner history proceeds with the enumeration of the years. Deviating from this, astronomy employs a different method of chronology. It calls the year in which Christ was born zero.

3 yr. B.C.|2 yr. B.C.|1 yr. B.C.|year 0|1 yr. A.D.|2 yr. A.D.|3 yr. A.D.

Our problem is concerned with the question whether one wishes to consider this year 0 as belonging to the first century after or before Christ. If it is included in the former, then the first post-Christian century ends on December 31, 99, and hence the beginning of the second century is on January 1, 100. Those who fix the beginning of our century on January 1, 1900, must recognize a year 0. It is doubtful, however, whether it is logical and admissible to introduce such a year. In any event, one would then come into conflict with the laws of arithmetic. Thus the difference between 25 A.D. and 15 B.C. amounts to 40 years; for $(+25) - (-15) = 40$. According to the astronomic method of enumeration, it is, however, 41 years. In order to arrive at correct results, one must, therefore, increase the number of the negative years by 1. Furthermore, the introduction of a year 0 appears to be objectionable from another point of view. Our numbers used to designate the years are ordinals. In old inscriptions one reads: In the 1648th year after the birth of our Lord. The Latin language uses only the ordinal numerals for the enumeration of the years: p. Chr. n. milesimo sescentesimo duodequinquagesimo. But is there really among the ordinal numerals a "zeroeth"? Obviously not at first sight. For in counting, one always begins with the first object. Thus a month has no zero day and the hour no zero minute. In the streets one finds no house with the number 0 and on measuring instruments there is no "zeroeth" centimeter. Zero as an ordinal number is used only whenever it designates a concept void of content, *e.g.*, the zero mark of a thermometer. In this sense one may speak of a milestone "zero." Consequently, there can be no "zeroeth" year. That it has nonetheless been established is based on the formal replacement of the ordinal numbers by the cardinal numbers. In this case one should, however, be consistent by designating, for instance, the current year as the 1950th after Christ. Astronomic dates of years of the pre-Christian era are, in order to conform to the historical method of counting, to be reduced algebraically by 1, for the zero mark in historical chronology is at the beginning of the first year A.D. Thereby the year 0 becomes the year 1 B.C., etc.

Book Review

Catalogue of 1440 new Variable Stars, with Information concerning the Nature of their Variation.

A pamphlet of 36 pages bearing the above title appeared in 1949, as a supplement to the *Astronomische Nachrichten*. It was prepared by Dr. Cuno Hoffmeister and represents the results of work done by him in 1945 and 1946 at the Sonnenberg Observatory. The investigation was carried out by the method of comparing plates in a stereocomparator. In the catalogue are listed the serial number of variables discovered at Sonnenberg, the 1855.0 position, the brightness at maximum and at minimum, the kind of variation, long-period, short-period, irregular, etc., and remarks when called for. It is a valuable addition to the rapidly growing volume of literature on Variable Stars. C.H.G.